#1
PATENT

12-5-03

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:

Manoharprasad K. Rao, et al.

Serial No.: 09/683,782 Group Art Unit: 2632

Filed: February 13, 2002 Examiner: Previl, Daniel

Title: METHOD FOR OPERATION A PRE-CRASH SENSING SYSTEM IN A VEHICLE HAVING A COUNTERMEASURE SYSTEM USING STEREO CAMERAS

Atty. Docket No.: 201-0634 (FGT 1536 PA)

I hereby certify that this correspondence is being deposited with the United States Postal Service as first class mail in an envelope addressed to: Mail Stop Appeal Brief - Patents, Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450 on

November 18, 2003 **Jo Anne Croskey** Jo Anne Croskey
(Date of Deposit) **(Signature)**

BRIEF ON APPEAL

Mail Stop Appeal Brief - Patents
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Sir:

The following Appeal Brief is submitted pursuant to the Notice of Appeal filed September 23, 2003, in the above-identified application. The Appeal Brief is being submitted in triplicate to comply with the provisions of 37 CFR 1.192(c). Please charge the $330.00 fee for filing the Brief on Appeal to Ford Deposit Account No. 06-1510.

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I. Real Party in Interest

The real party in interest in this matter is The Ford Global Technologies, Inc. in Dearborn, Michigan (hereinafter "Ford") is the assignee of the present invention and application.

II. Related Appeals and Interferences

There are no other known appeals or interferences, which will directly affect or be directly affected by or have a bearing on the Board's decision in the pending appeal.

III. Status Of The Claims

Claims 1-17 are currently pending and stand under final rejection, from which this appeal is taken. A copy of the claims on appeal is attached as an Appendix.

IV. Status Of Amendments

On May 23, 2003, a Request for Reconsideration was filed, prior to the Final Office Action, which provided remarks for the allowance of claims 1-17. There have been no amendments filed.

V. Summary Of The Invention

By way of summary, the present invention is directed to systems and methods of operating a pre-crash sensing system for an automotive vehicle. Claims 1 and 7 encompass several points of novelty, and since claims 2-6 and 8-17 depend from claims 1 and 7, respectively, they also contain at least the same points of novelty.

Claim 1 recites a pre-crash sensing system 10 coupled to a countermeasure system 40 having at least a first countermeasure and a second countermeasure. The pre-crash sensing system 10 includes a vision system 26 that generates an object size signal and an object distance signal. A controller 12 is coupled to the vision system 26 and deploys either the first countermeasure or the first and the second countermeasure in response to the object distance signal and the object size signal.

Claim 7 has similar limitations to that of claim 1. Claim 7 recites a method of operating a pre-crash sensing system, such as the sensing system 10, for an automotive vehicle having a countermeasure system, such as the countermeasure system 40. A decision zone relative to the vehicle is established. An object within the decision zone is detected using a vision system, such as the vision system 26. An object distance and relative velocity is determined using the vision system. Object size is also determined. The countermeasure system is activated in response to the object size and the relative velocity.

A vision system, as stated in paragraph [0025] of the present application, may include one or more cameras, CCD devices, or CMOS type devices. The vision system may be used to determine object parameters, such as object distance, velocity, size, and cross-sectional area. A vision system is not the same as a radar-based system. A radar system typically consists of generating and transmitting a radar beam and detecting reflection of that beam on obstacles within a detection zone. However, a vision system, in general, receives light from within and emitted or reflected from objects in a detection zone. A radar system is more of an active system, whereas a vision system is more of a passive system. Also, a vision system, in general, provides increased amount of and more accurate object information over that of a radar system. Thus, a vision system better aids a pre-crash sensing system in the proper and accurate activation of countermeasures over that of a radar system.

Both the pre-crash sensing system 10 and the method of operating a pre-crash sensing system, as recited in claims 1 and 7, determine object size using a vision system and in response thereto perform countermeasures. In using a vision system object size can be accurately detected. Also, by knowing the size of a detected object, different countermeasures and different counter measure activation modes may be chosen. Performing a countermeasure in response to the size of an object also minimizes unintentional and inadvertent activation of countermeasure devices.

Applicants admit that the prior art within the field of pre-crash sensing systems has included the use of radar to determine speed, direction, height, width, and distance data of an obstacle. What is not known or suggested is the several novel aspects of the present invention, which are utilized in combination. All of the novel

aspects of the present invention are not taught or suggested by the prior art separately or in combination. The novel aspects are described in detail below.

What is not known or suggested is the use of a vision system to determine object size, distance, and velocity. What is also not known or suggested is the deployment of countermeasures in response to the vision system 26 determined object size, distance, and velocity parameters 28 and 30.

Claim 2 recites the system of claim 1 wherein the vision system includes a stereo pair of cameras.

Claim 3 recites the system of claim 1 wherein the object size includes height.

Claim 4 recites the system of claim 1 wherein the object size includes object area and object height.

Claim 5 recites the system of claim 1 further including a vehicle speed sensor 32 that generates a speed signal that corresponds to the longitudinal speed of the vehicle. The controller 12 activates the countermeasure system 40 in response to the longitudinal speed signal.

Claim 6 recites the system of claim 1 further including a decision zone. The vision system 26 detects an object and generates an object distance signal from an object within the decision zone.

Claim 8 recites the method of claim 7 wherein determining object size includes determining an object height. Also, when activating the countermeasure system in response to the object size, the countermeasure system 40 is activated in response to object height.

Claim 9 recites the method of claim 7 wherein determining object size includes determining an object cross-sectional area. Also, when activating the countermeasure system 40 in response to the object size, the countermeasure system 40 is activated in response to the object cross-sectional area.

Claim 10 recites the method of claim 7 wherein determining object size includes determining an object cross-sectional area and an object height. Also, when activating the countermeasure system 40 in response to the object size, the

countermeasure system 40 is activated in response to the object cross-sectional area and an object height.

Claim 11 recites the method of claim 10 wherein determining object size includes determining an object cross-sectional area with a vision system 26.

Claim 12 recites the method of claim 7 wherein detecting an object within the decision zone includes detecting the object within the decision zone with a stereo pair of cameras 28 and 30.

Claim 13 recites the method of claim 7 wherein prior to the step of activating the countermeasure system 40 either the first countermeasure or the first countermeasure and the second countermeasure are selected in response to the object size.

Claim 14 recites the method of claim 7 wherein determining object size includes determining the vehicle orientation. Also, when activating the countermeasure system 40 in response to the object size, the countermeasure system 40 is activated in response to the object size and the vehicle orientation.

Claim 15 recites the method of claim 7 further including establishing a decision zone in front of the vehicle.

Claim 16 recites the method of claim 15 further including detecting an object within the decision zone and activating the countermeasure in response to detecting an object within the decision zone.

Claim 17 recites the method of claim 7 wherein activating the countermeasure system 40 includes activating a first countermeasure, which includes pre-arming airbags and pretensioning motorized belt pretensioners, or activating the first countermeasure and a second countermeasure. The second countermeasure includes adjusting the host vehicle suspension height in response to the object size and orientation.

VI. Issues

The following issues are presented in this appeal, which correspond directly to the Examiner's final grounds for rejection in the Final Office Action dated August 12, 2003:

(1) whether claim 1 is patentable under 35 U.S.C. 102(b) as being anticipated by Cho (USPN 5,959,552),

(2) whether claim 1 is patentable under 35 U.S.C. 103(a) over Shirai (USPN 6,018,308) in view of Miller et al. (USPN 6,442,484),

(3) whether claims 2-6 are patentable under 35 U.S.C. 103(a) over Shirai in view of Miller and further in view of Kinoshita et al. (USPN 6,114,951),

(4) whether claims 7-11 are patentable under 35 U.S.C. 103(a) over Shirai in view of Miller, and

(5) whether claims 12-17 are patentable under 35 U.S.C. 103(a) over Shirai in view of Miller and further in view of Kinoshita.

VII. Grouping of Claims

The rejected claims have been grouped together by the Patent Office Examiner in the rejection. The Appellants state, however, that each of the rejected claims stand on their own recitation and are separately patentable for the reasons set forth in more detail below.

VIII. Argument

A. THE REJECTION OF CLAIM 1 UNDER 35 U.S.C. § 102(b)

Claim 1 stand fully rejected under 35 U.S.C. § 102(b) as being anticipated by Cho.

Cho discloses a system for minimizing automobile collision damage and personal injury. Cho discloses a radar detection sensor unit 60 that is used to determine speed, direction, and distance data of an obstacle. Cho alters speed of a host vehicle and actuates air bags in response to the speed of the obstacle.

Cho does not teach or suggest use of a vision system nor does Cho teach or suggest use of a vision system to detect object size. Cho uses radar, which is not the same as a vision system, as defined by the present application. Also, Cho uses radar to determine direction and distance information, but does not use radar to detect object size.

The First Office Action and the Final Office Action refer to col. 11, lines 44-47, of Cho for the teaching of generating an object size signal. This section of Cho simply states that the radar of Cho is capable of detecting a small object, not the size of the object. Applicants submit that the ability to detect small objects is not the same as the ability to determine size of objects and is also not the same as the ability to distinguish between sizes of objects. Applicants also submit that although a system is capable of detecting a small object, the system is not inherently capable of determining size of an object. Additionally, the detection of an object does not suggest the subsequent step of determining size of an object.

For example, a radar-based object detection system may have precision necessary to detect small objects, may be able to determine relative distance and velocity of the objects, and may in response to the distance and velocity estimate the threat of the objects. The threat determination may be performed without use of object size. Also, several less complex and costly radar-based systems are incapable of determining size of an object. Thus, a system that is capable of detecting objects is not inherently capable of determining size of the objects and the detection of an object does not suggest the subsequent step of determining size of an object.

Furthermore, Cho does not teach or suggest the determining of object size and the use of the object size to perform a countermeasure. Cho discloses the alteration of host vehicle speed and the actuation of air bags in response to the speed of a detected obstacle. Speed of an obstacle is clearly not the same as the size of the object. Also, unintentional and inadvertent alteration or activation of a countermeasure can occur when performing such alteration and actuation in response to speed of an obstacle alone. In addition, since Cho does not determine object size, Cho is unable to determine threat of objects and perform threat level comparisons of objects to the extent of the system, as claimed in claim 1 of the present application. The system as claimed in claim 1, by being able to determine object size, is capable of determining which of several detected objects is larger and thus, is better capable of determining which object poses a greater threat.

Therefore, applicants respectfully submit that the combinations in claim 1 are not found in the prior art.

Claim 2 is believed to be allowable for the reasons set forth above since it depends from claim 1 and further recites that the vision system 26 includes a stereo pair of cameras 28 and 30. Neither of the references teach nor suggest this combination.

Claim 3 is believed to be allowable for the reasons set forth above since it depends from claim 1 and further recites that the object size includes height. Neither of the references teach nor suggest this combination.

Claim 4 is believed to be allowable for the reasons set forth above since it depends from claim 1 and further recites that the object size includes object area and object height. Neither of the references teach nor suggest this combination.

Claim 5 is believed to be allowable for the reasons set forth above since it depends from claim 1 and further recites the use of a vehicle speed sensor 32 that generates a speed signal that corresponds to the longitudinal speed of the vehicle. The controller 12 activates the countermeasure system 40 in response to the longitudinal speed signal. Neither of the references teach nor suggest this combination.

Claim 6 is believed to be allowable for the reasons set forth above since it depends from claim 1 and further recites the use of a decision zone. The vision sensor 26 detects an object and generates an object distance signal from an object within the decision zone. Neither of the references teach nor suggest this combination.

B. THE REJECTION OF CLAIMS 1 AND 7 UNDER 35 U.S.C. § 103(a)

Claims 1 and 7 stand finally rejected under 35 U.S.C. 103(a) over Shirai in view of Miller.

As stated in the Response to the First Office Action, Shirai is directed towards an automotive collision avoidance or obstacle recognition system 1 for an automotive vehicle. Shirai discloses a radar unit 31 and 33 for determining height and distance of an object. Although Shirai may determine object height using a radar unit, Shirai does not teach or suggest the use of a vision system or the use of a vision system to determine object size. The Final Office Action relies on Shirai for the teaching of a

vision system. As stated above and as defined by the present application, a vision system is not the same as a radar unit.

Shirai also, as stated in the Response to the First Office Action, fails to teach or suggest a controller coupled to a vision system and the deployment of either a first countermeasure or a first countermeasure and a second countermeasure in response to an object distance signal and an object size signal.

Miller is directed towards a method for pre-crash assessment using spheroidal partitioning. Miller discloses use of a radar sensor 29 to determined distance of an object. Miller activates a countermeasure in response to distance of the object. Miller as with Shirai, also does not teach or suggest use of a vision system and deployment of a countermeasure in response to an object distance signal and an object size signal. Nowhere in Miller is object size detected, determined, or used to perform any countermeasures.

The Final Office Action relies on Miller for the teaching of a controller that performs the functions as claimed in claims 1 and 7 of the present application and, in so doing, states that Miller discloses the controller 300 coupled to the radar sensor 29 and the proximity detector 42. The inclusion of a controller does not imply that the included controller, namely controller 300, is the same as or performs the same functions as the claimed controller 12. Clearly, the controller 300 of Miller is not the same as the controller 12 as claimed. The controller of Miller simply activates countermeasures in response to the distance of an object as determined through use of the radar sensor 29 and the proximity detector 42. The controller 12, claimed in claims 1 and 7 of the present invention, determines size of the detected objects through use of the vision system 26 and performs countermeasures in response to the size of the objects.

The Final Office Action states that the proximity detector 42 in determining proximity of various vehicles, inherently determines object size. Nowhere in Miller is object size mentioned, suggested, or determined. Applicants submit that determining distance of an object is not the same as determining object size. Also, the act of determining distance of an object does not imply that object size is also determined.

Applicants agree that the test for combining references is what the combination of disclosures, taken as a whole, would suggest to one of ordinary skill in the art, *In re McLaughlin*, 170 USPQ 209 (CCPA 1971). On the other hand, Applicants do not agree that the combination of Shirai and Miller is proper and that there combination teach or suggest each and every element as recited in claims 1 and 7. Neither Shirai nor Miller alone or in combination teach or suggest use of a vision system. Neither Shirai nor Miller alone or in combination teach or suggest deployment of a countermeasure in response to either an object distance signal and an object size signal or in response to object size and relative velocity, as generated or detected by a vision system. One cannot arrive at the system and method of claims 1 and 7 of the present application by combining the teachings of Shirai with that of Miller. Therefore, applicants respectfully submit that the combinations in claim 1 and 7 are not found in the prior art.

Claim 2 is believed to be allowable for the reasons set forth above since it depends from claim 1 and further recites that the vision system 26 includes a stereo pair of cameras 28 and 30. Neither of the references teach nor suggest this combination.

Claim 3 is believed to be allowable for the reasons set forth above since it depends from claim 1 and further recites that the object size includes height. Neither of the references teach nor suggest this combination.

Claim 4 is believed to be allowable for the reasons set forth above since it depends from claim 1 and further recites that the object size includes object area and object height. Neither of the references teach nor suggest this combination.

Claim 5 is believed to be allowable for the reasons set forth above since it depends from claim 1 and further recites the use of a vehicle speed sensor 32 that generates a speed signal that corresponds to the longitudinal speed of the vehicle. The controller 12 activates the countermeasure system 40 in response to the longitudinal speed signal. Neither of the references teach nor suggest this combination.

Claim 6 is believed to be allowable for the reasons set forth above since it depends from claim 1 and further recites the use of a decision zone. The vision sensor 26 detects an object and generates an object distance signal from an object within the decision zone. Neither of the references teach nor suggest this combination.

Claim 8 is believed to be allowable for the reasons set forth above since it depends from claim 7 and further recites determining an object height in determining object size. Also, when activating the countermeasure system 40 in response to the object size, the countermeasure system 40 is activated in response to object height. Neither of the references teach nor suggest this combination.

Claim 9 is believed to be allowable for the reasons set forth above since it depends from claim 7 and further recites determining an object cross-sectional area in determining object size. Also, when activating the countermeasure system 40 in response to the object size, the countermeasure system 40 is activated in response to the object cross-sectional area. Neither of the references teach nor suggest this combination.

Claim 10 is believed to be allowable for the reasons set forth above since it depends from claim 7 and further recites determining an object cross-sectional area and an object height in determining object size. Also, when activating the countermeasure system 40 in response to the object size, the countermeasure system 40 is activated in response to the object cross-sectional area and an object height. Neither of the references teach nor suggest this combination.

Claim 11 is believed to be allowable for the reasons set forth above since it depends from claim 10 and further recites determining an object cross-sectional area with a vision system 26 in determining object size. Neither of the references teach nor suggest this combination.

Claim 12 is believed to be allowable for the reasons set forth above since it depends from claim 7 and further recites detecting the object within the decision zone with a stereo pair of cameras 28 and 30 in detecting an object within the decision zone. Neither of the references teach nor suggest this combination.

Claim 13 is believed to be allowable for the reasons set forth above since it depends from claim 7 and further recites prior to the step of activating the countermeasure system 40 either the first countermeasure or the first countermeasure and the second countermeasure are selected in response to the object size. Neither of the references teach nor suggest this combination.

Claim 14 is believed to be allowable for the reasons set forth above since it depends from claim 7 and further recites determining the vehicle orientation in

determining object size. Also, when activating the countermeasure system 40 in response to the object size, the countermeasure system 40 is activated in response to the object size and the vehicle orientation. Neither of the references teach nor suggest this combination.

Claim 15 is believed to be allowable for the reasons set forth above since it depends from claim 7 and further recites establishing a decision zone in front of the vehicle. Neither of the references teach nor suggest this combination.

Claim 16 is believed to be allowable for the reasons set forth above since it depends from claim 15 and further recites detecting an object within the decision zone and activating the countermeasure in response to detecting an object within the decision zone. Neither of the references teach nor suggest this combination.

Claim 17 is believed to be allowable for the reasons set forth above since it depends from claim 7 and further recites activating a first countermeasure, which includes pre-arming airbags and pretensioning motorized belt pretensioners, or activating the first countermeasure and a second countermeasure in activating the countermeasure system 40. The second countermeasure includes adjusting the host vehicle suspension height in response to the object size and orientation. Neither of the references teach nor suggest this combination.

C. THE REJECTION OF CLAIMS 2-6 UNDER 35 U.S.C. § 103(a)

Claims 2-6 stand finally rejected under 35 U.S.C. 103(a) over Shirai in view of Miller and further in view of Kinoshita. Applicants submit that since the combinations of claim 1 are not found in the prior art, that the combinations of claims 2-6 are also not found in the prior art for at least the same reasons.

D. THE REJECTION OF CLAIMS 8-11 UNDER 35 U.S.C. § 103(a)

Claims 8-11 stand finally rejected under 35 U.S.C. 103(a) over Shirai in view of Miller. Applicants submit that since the combinations of claim 7 are not found in the prior art, that the combinations of claims 8-11 are also not found in the prior art for at least the same reasons.

E. THE REJECTION OF CLAIMS 12-17 UNDER 35 U.S.C. § 103(a)

Claims 12-17 stand finally rejected under 35 U.S.C. 103(a) over Shirai in view of Miller and further in view of Kinoshita. Applicants submit that since the combinations of claim 7 are not found in the prior art, that the combinations of claims 12-17 are also not found in the prior art for at least the same reasons.

IX. Appendix

A Copy of U.S. Patents 5,959,552 to Cho, 6,018,308 to Shirai, 6,442,484 to Miller, and 6,114,951 Kinoshita are attached hereto as Appendix A.

A copy of the claims involved in this appeal, namely claims 1-17, is attached hereto as Appendix B.

X. Conclusion

For the reasons advanced above, Appellants respectfully contend that each claim is patentable. Therefore reversal of the rejection is requested.

Respectfully submitted,

Jeffrey J. Chapp, Reg. No. 50,579
Attorney for Assignee
Artz & Artz, P.C.
28333 Telegraph Road, Suite 250
Southfield, MI 48034
(248) 223-9500

Dated: November 18, 2003

APPENDIX A

Copy of U.S. Patents 5,959,552 to Cho, 6,018,308 to Shirai, 6,442,484 to Miller, and 6,114,951 Kinoshita

United States Patent [19]
US005959552A

Cho

[11] Patent Number: 5,959,552

[45] Date of Patent: Sep. 28, 1999

[54] SYSTEM FOR MINIMIZING AUTOMOBILE COLLISION DAMAGE AND PERSONAL INJURY

[76] Inventor: Myungeun Cho, 13404 Tossa La., Austin, Tex. 78729

[*] Notice: This patent is subject to a terminal disclaimer.

[21] Appl. No.: 08/859,647

[22] Filed: May 20, 1997

Related U.S. Application Data

[63] Continuation-in-part of application No. 08/650,869, May 20, 1996, Pat. No. 5,646,613.

[51] Int. Cl.[6] G08G 1/16

[52] U.S. Cl. 340/903; 340/94; 340/435; 180/167; 180/169; 280/730.2

[58] Field of Search 340/903, 904, 340/425.5, 435, 436; 180/167, 169, 274; 280/730.1, 730.2, 736, 737, 741; 342/70, 71, 72

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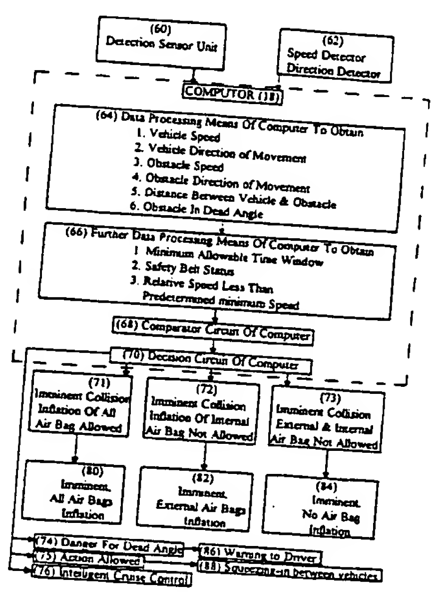
5,626,359	5/1997	Stefferns, Jr. et al.	280/735
5,684,473	11/1997	Hibino et al.	340/903

Primary Examiner—Daniel J. Wu
Assistant Examiner—Van T. Trien
Attorney, Agent, or Firm—Richard C. Litman

[57] ABSTRACT

A system for minimizing roadway vehicle damage and personal injury which includes a detection sensor unit, a computer processing unit (CPU), and energy absorbing inflation devices. The detection sensor unit, which is mounted on the roadway vehicle to detect the speed, distance and direction of a potential obstacle, includes a transmitter for transmitting signals and a directional receiver to receive signals reflected by the potential obstacle and generates an electronic signal in response thereto. The CPU, which receives information on the speed and direction of the roadway vehicle and receives signals from the detection sensor unit continuously processes the information and signals and calculates changes in the speed, distance and direction of the potential obstacle with respect to the roadway vehicle. The CPU generates a control signal upon calculation of an imminent collision situation, which calculation is based on a predetermined minimum allowable time window. The minimum allowable time window is generally defined as a time period during which a driver of the roadway vehicle is unable to take evasive action, such as braking or turning the steering wheel, to avoid a collision situation. Each of the energy absorbing inflation devices includes an electronically controlled valve, with at least one of the energy absorbing inflation devices being responsive to the control signal. An external air bag is coupled to the valve of one of the energy absorbing inflation devices and an internal air bag is coupled to the valve of another of the inflation devices, such that upon calculation by the CPU of the imminent collision situation based on the predetermined minimum allowable time window, the CPU transmits the control signal to one of the energy absorbing inflation devices to deploy the air bags prior to the time of actual collision.

3 Claims, 19 Drawing Sheets



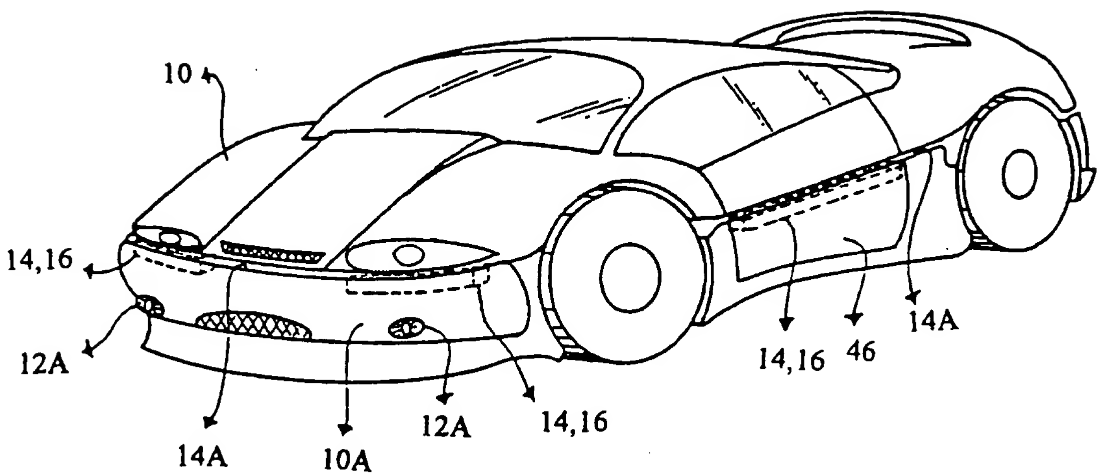
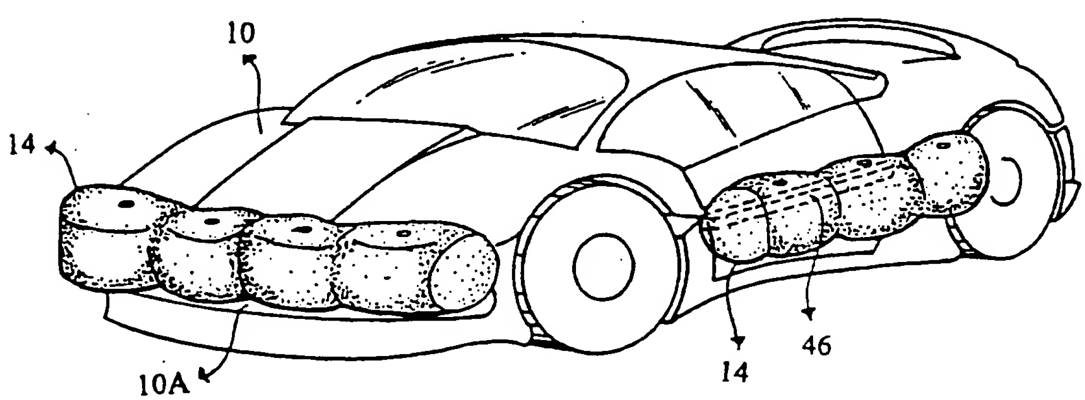


FIG 1



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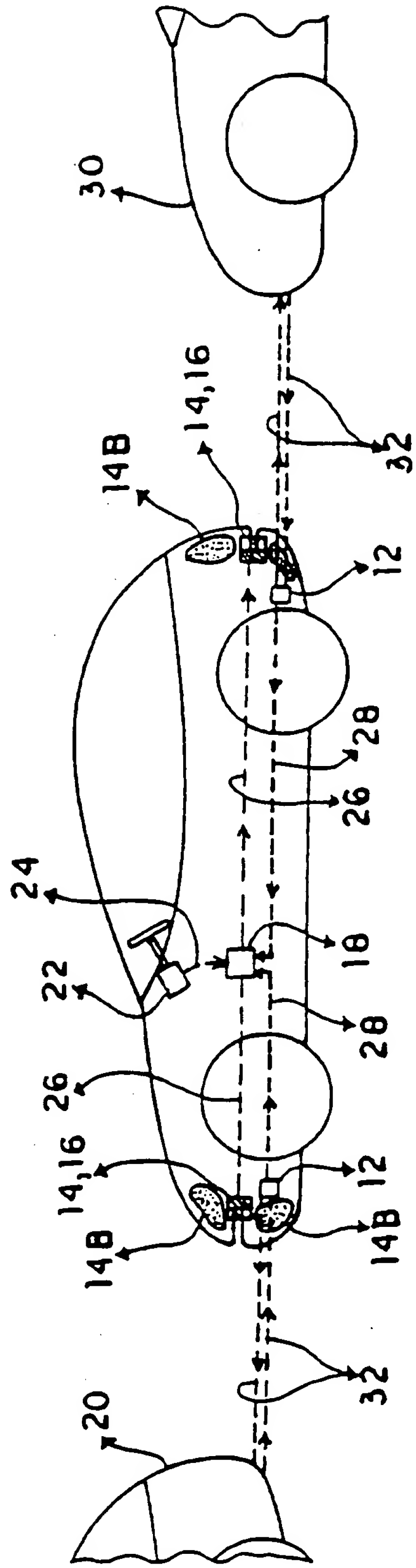
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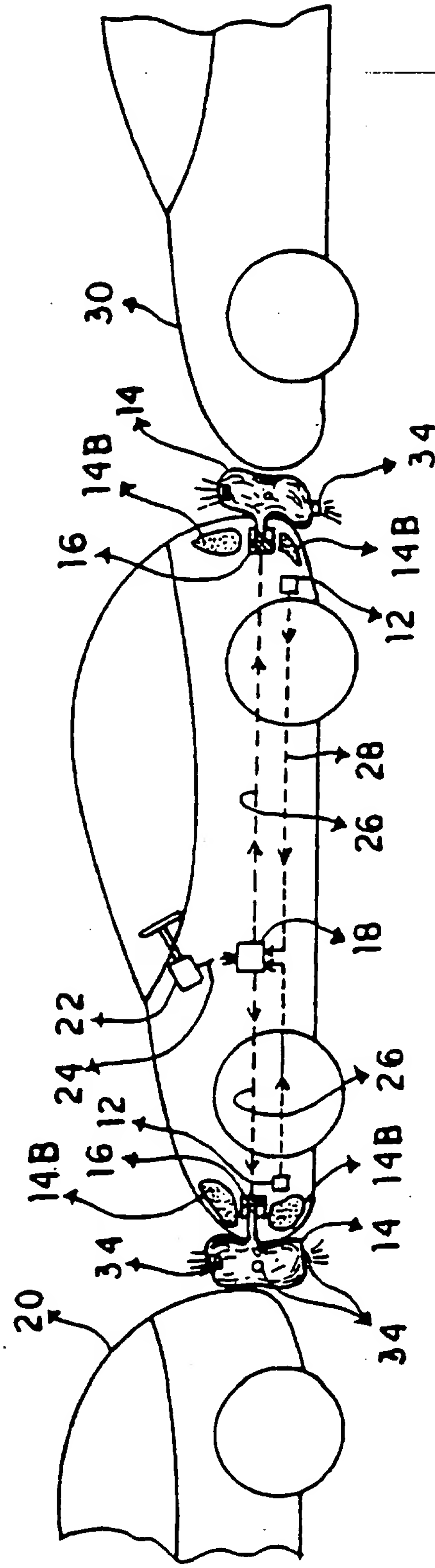
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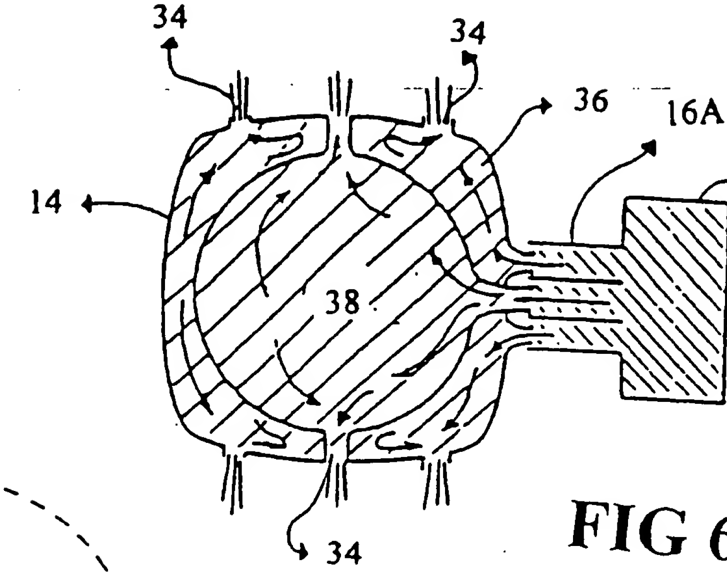

FIG 6A

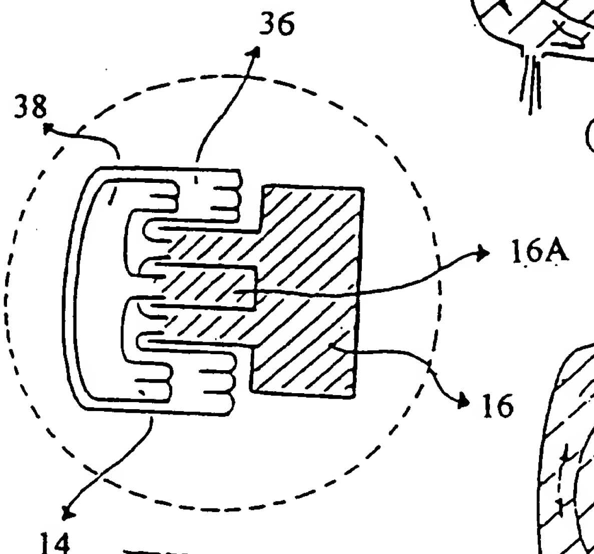

FIG 5

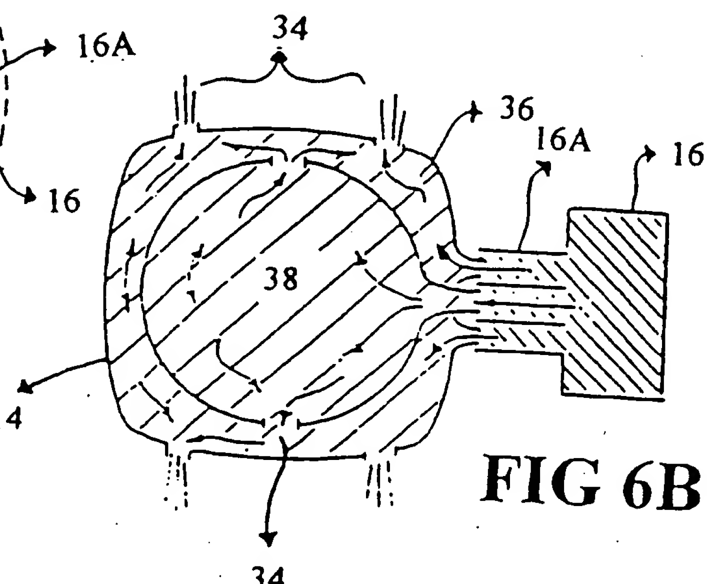

FIG 6B

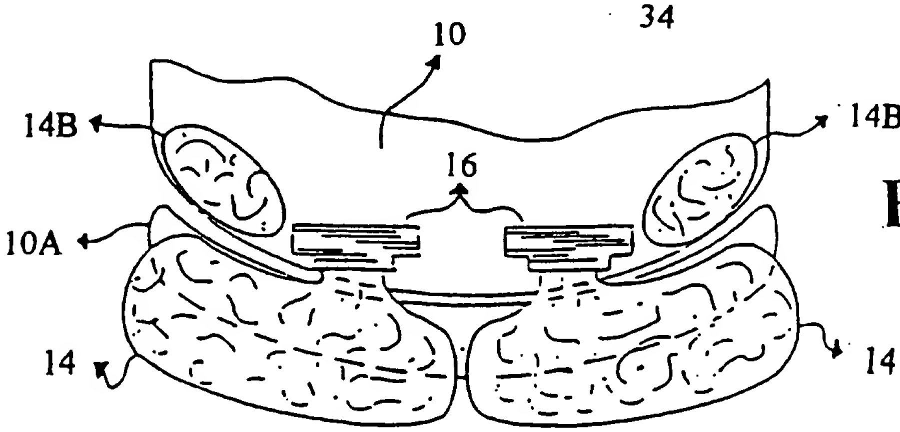

FIG 6

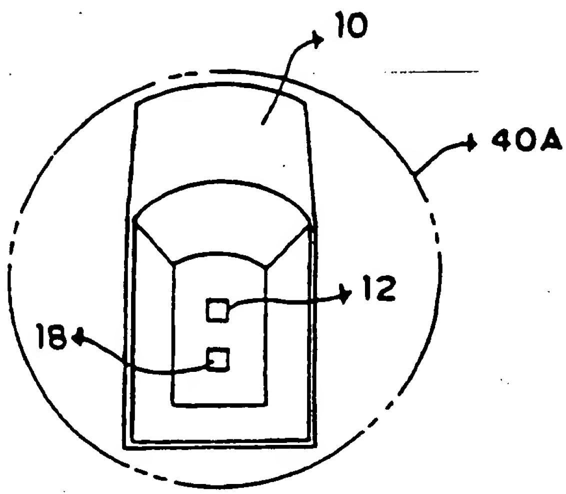

FIG 7

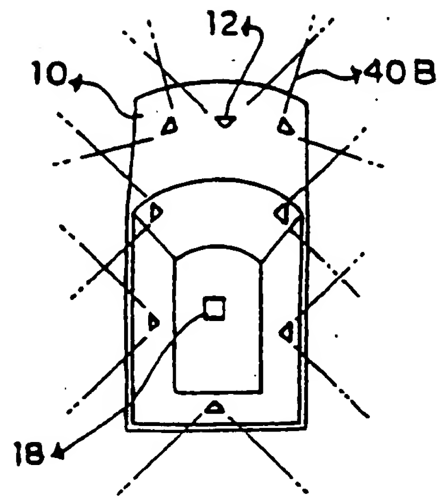

FIG 8

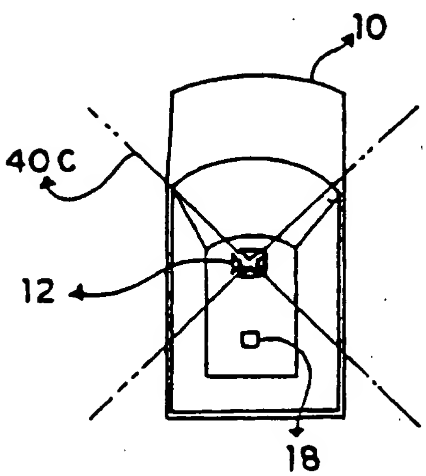

FIG 9

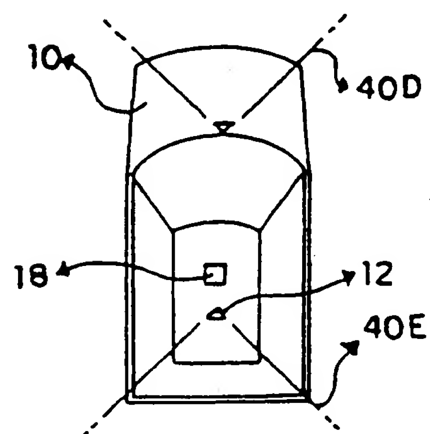

FIG 10

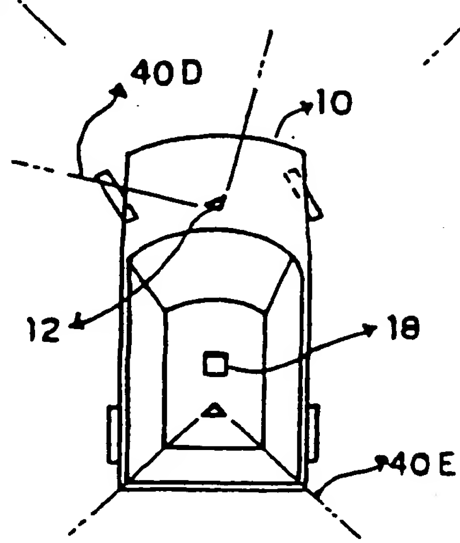

FIG 11

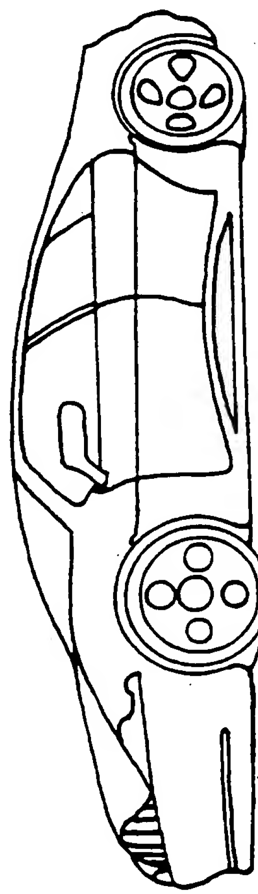

FIG 12

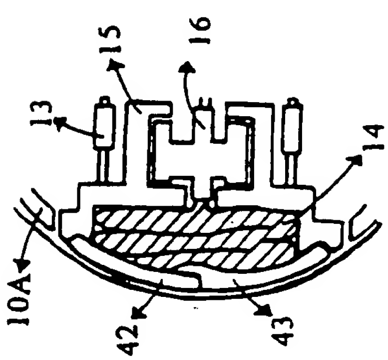

FIG 13

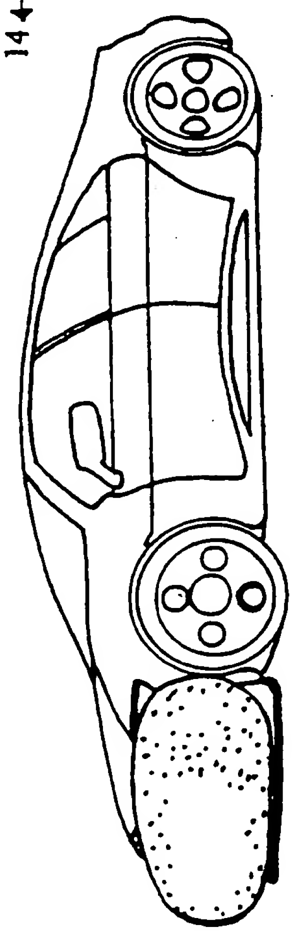

FIG 14

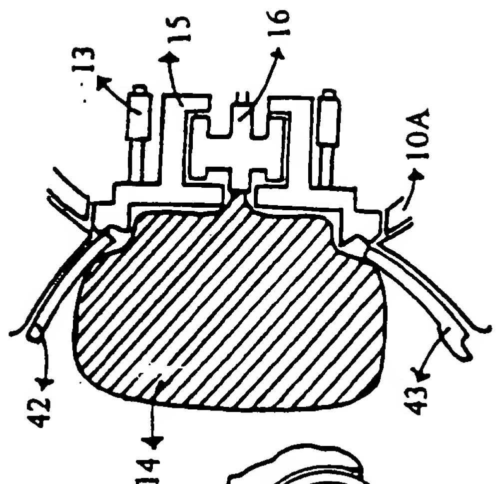

FIG 15

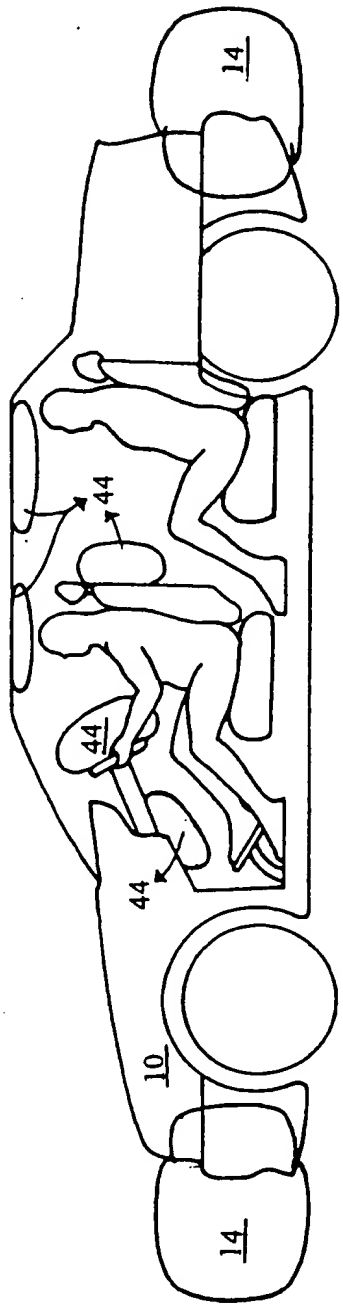

FIG 16

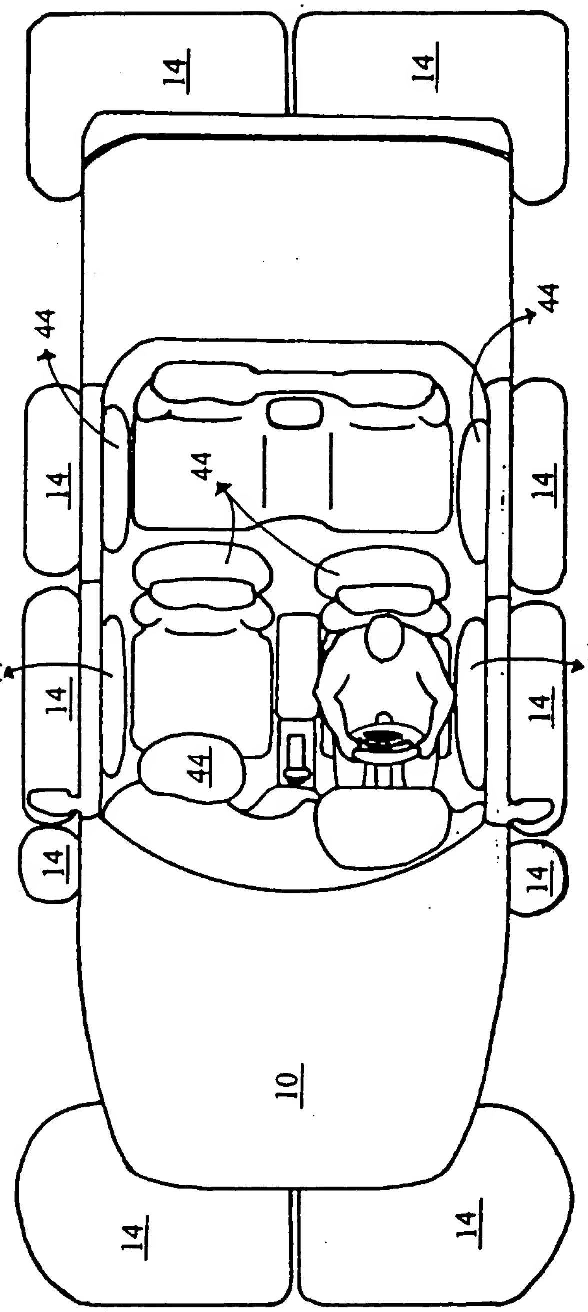

FIG 17

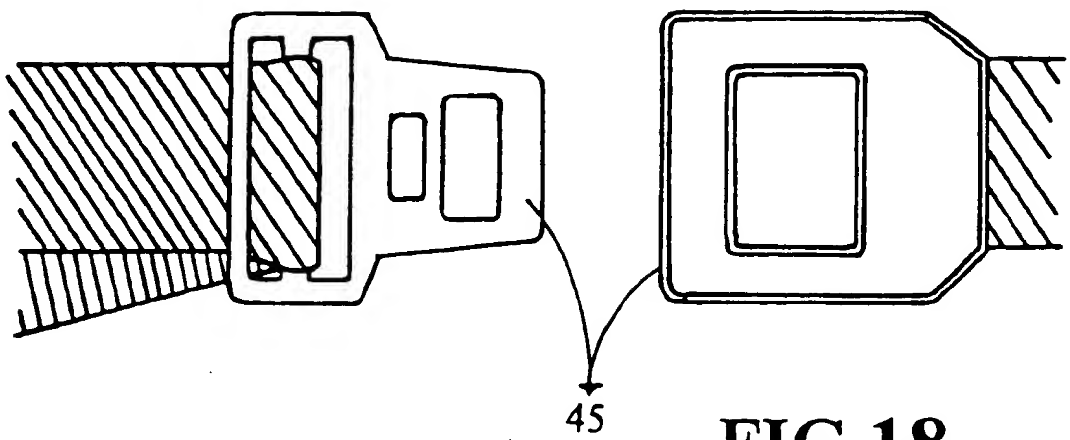

FIG 18

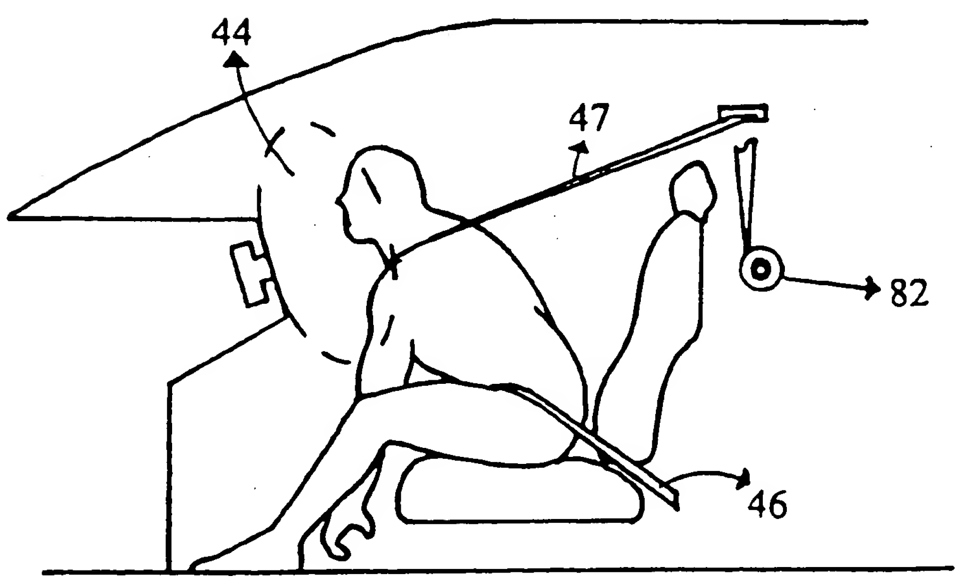

FIG 19

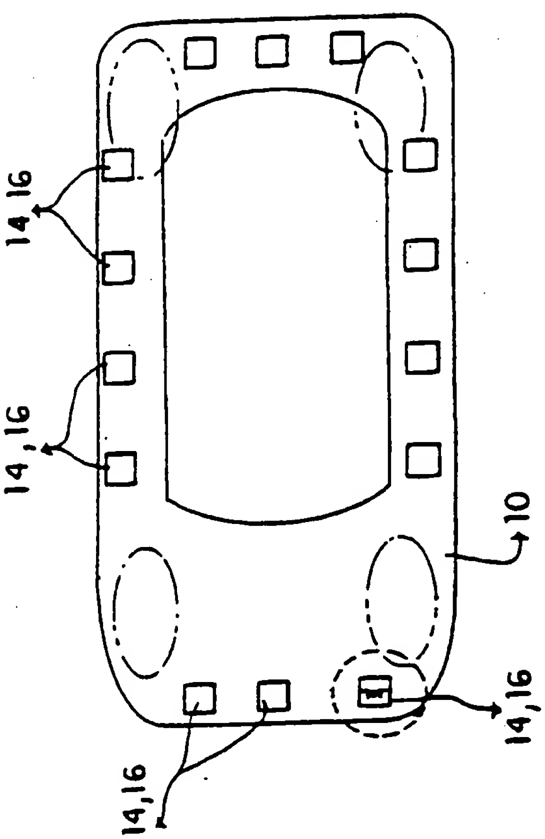

FIG 20

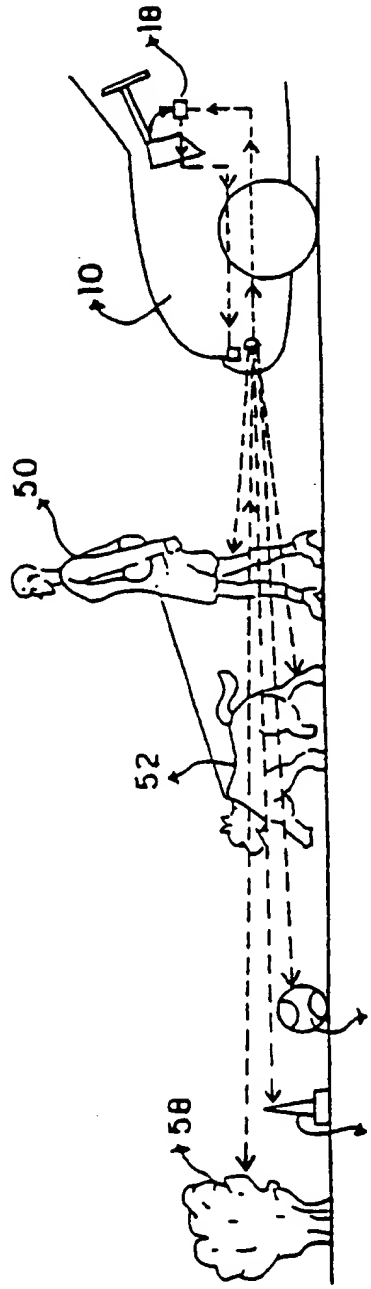

FIG 21

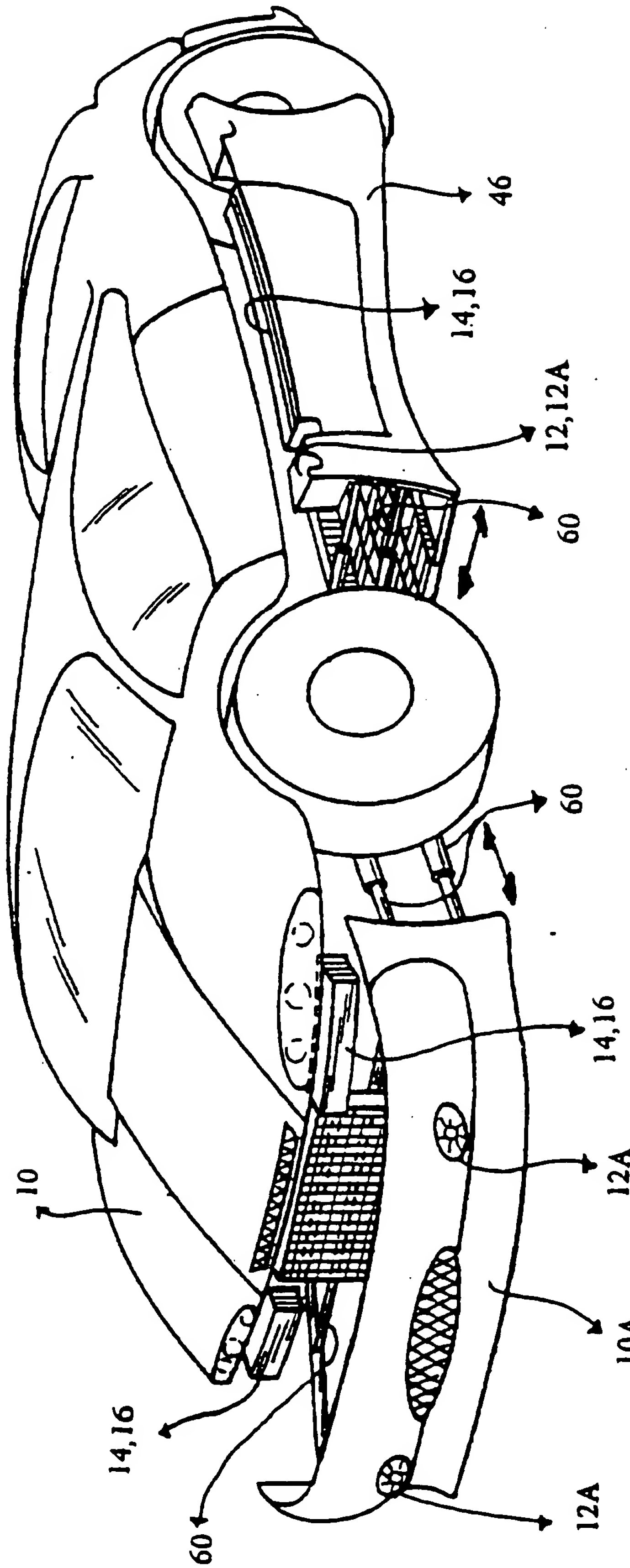

FIG 22

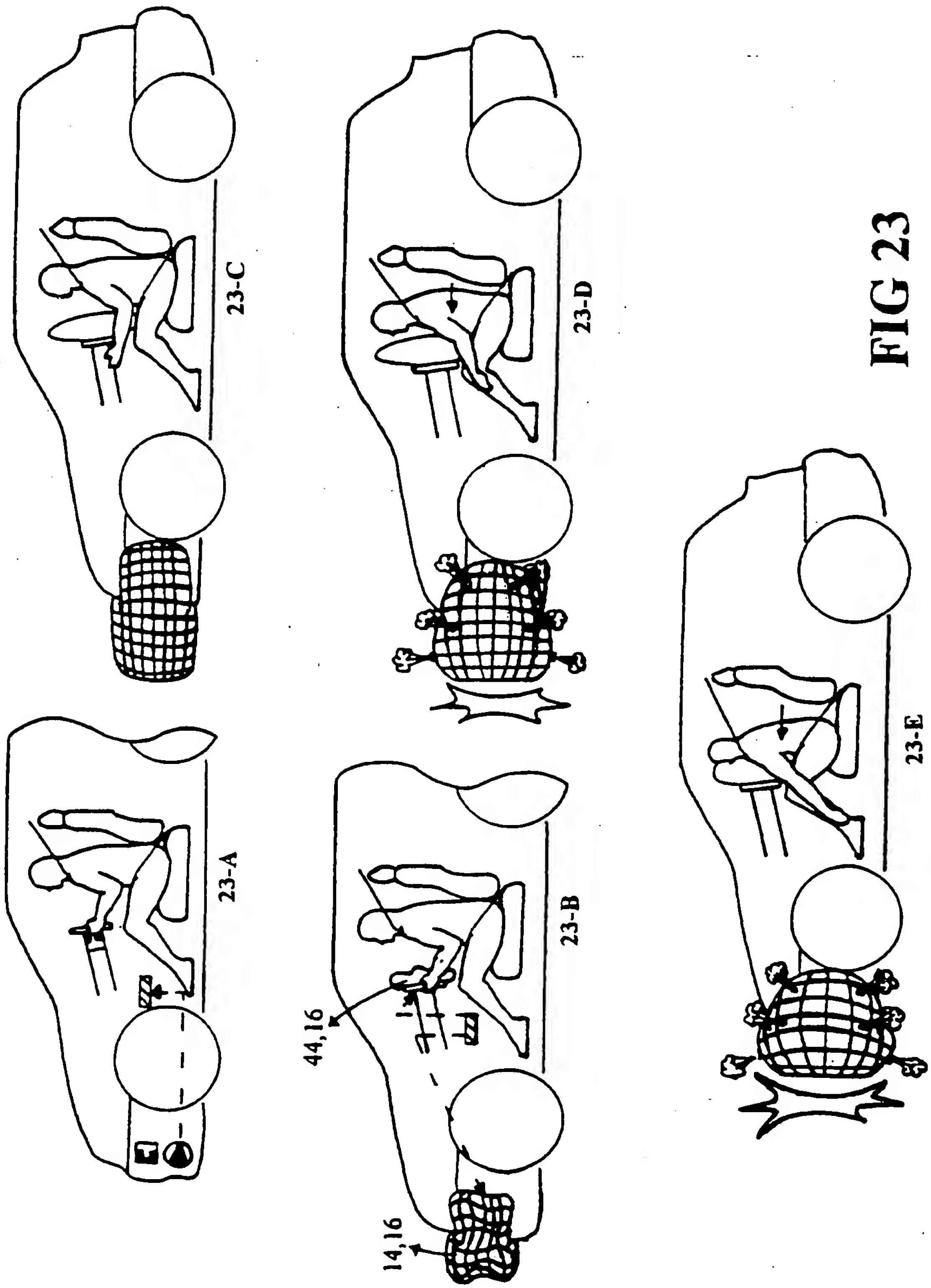

FIG 23

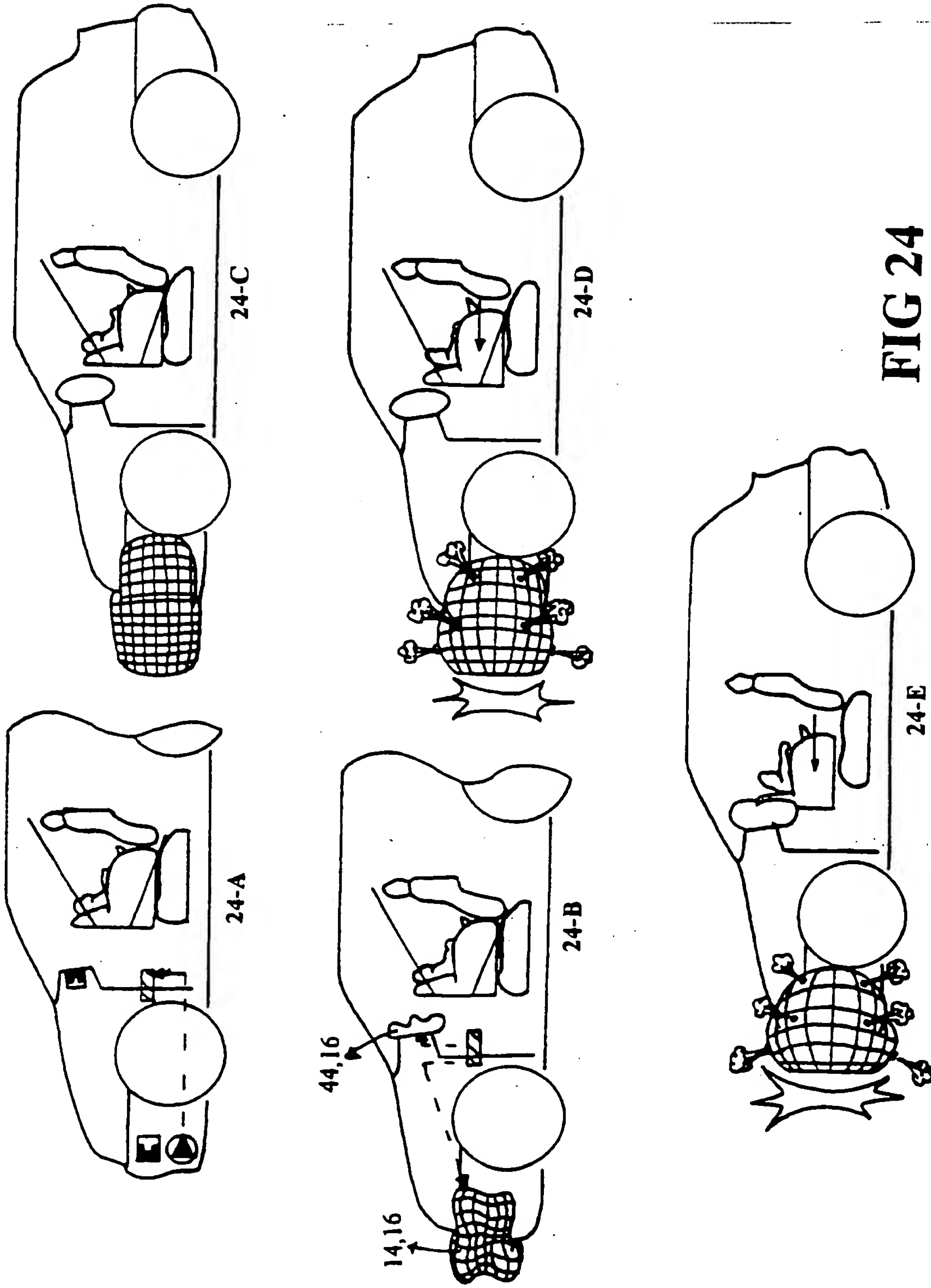

FIG 24

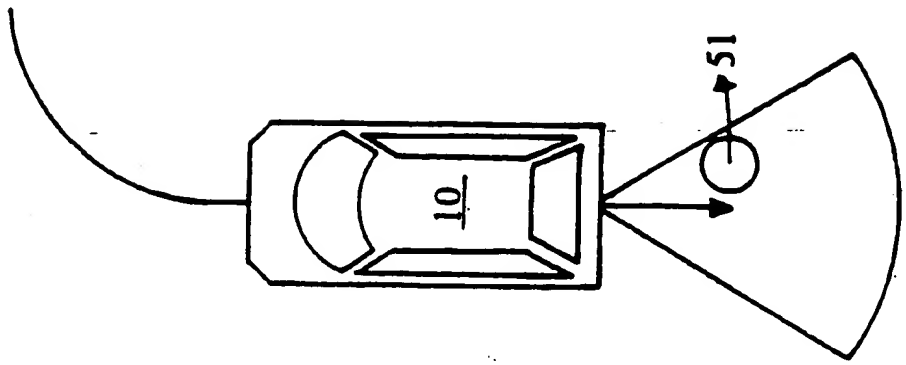

FIG 26

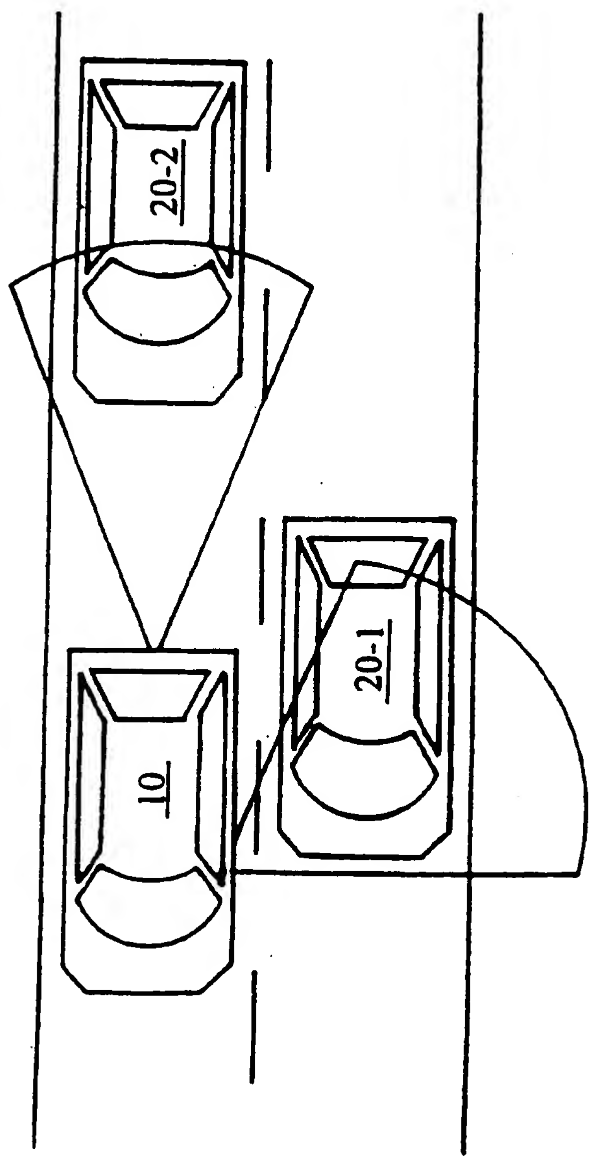

FIG 25

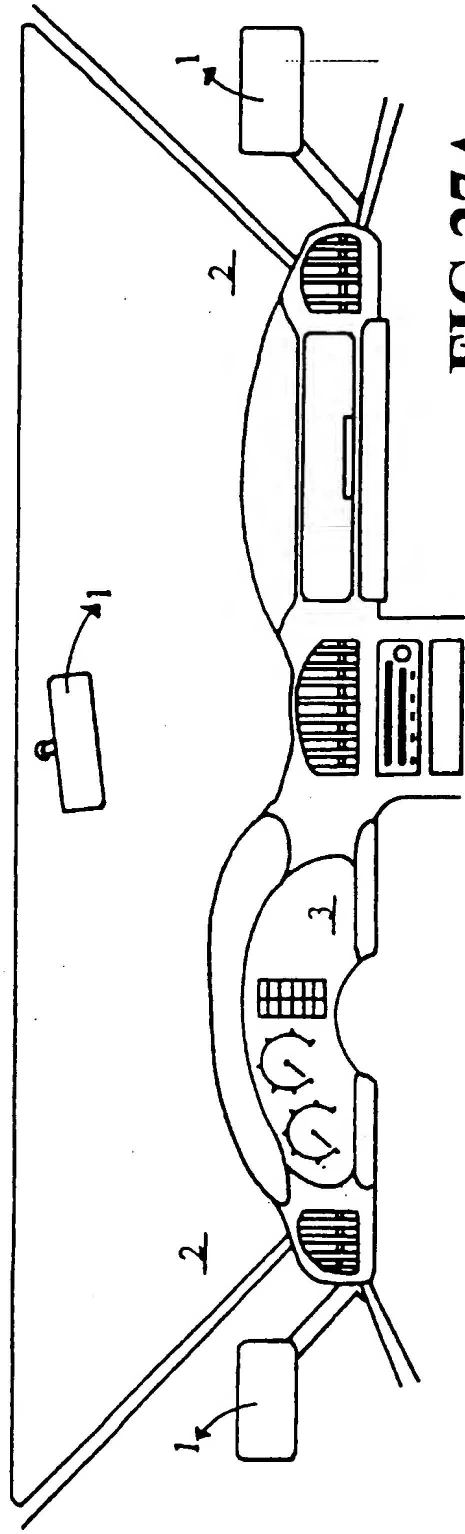

FIG 27A

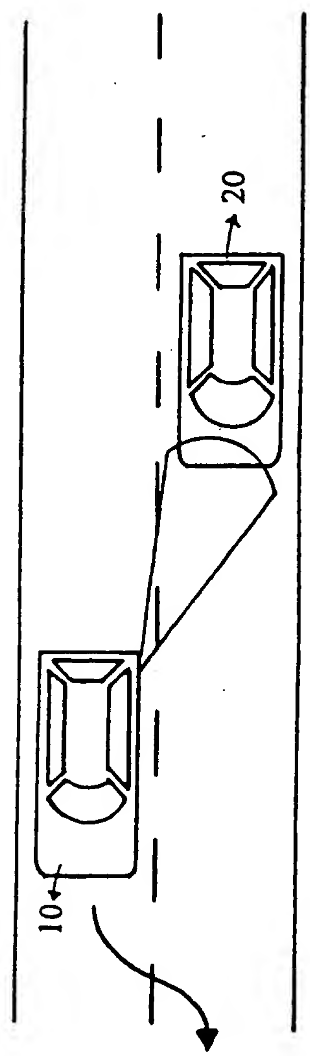

FIG 27

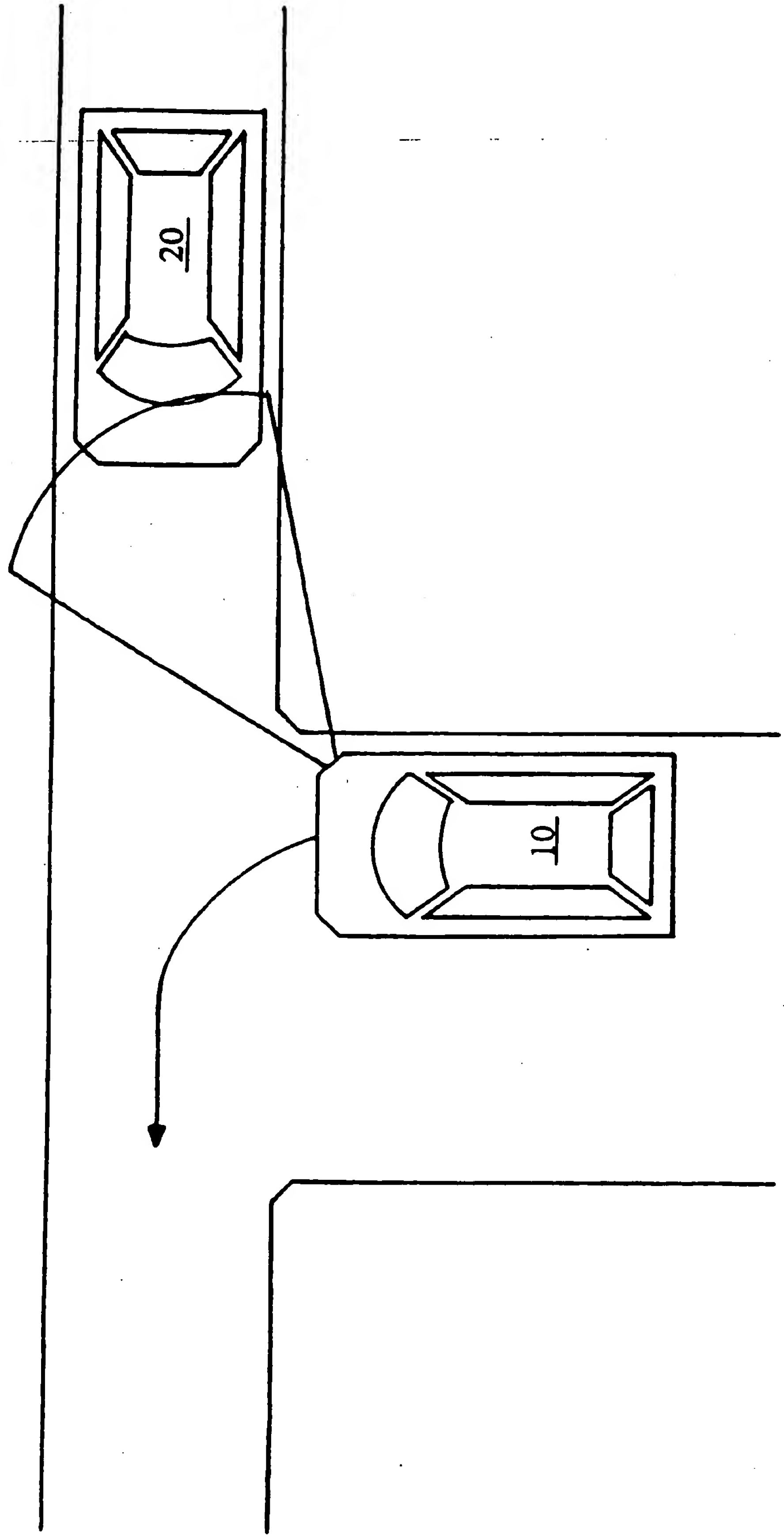

FIG 28

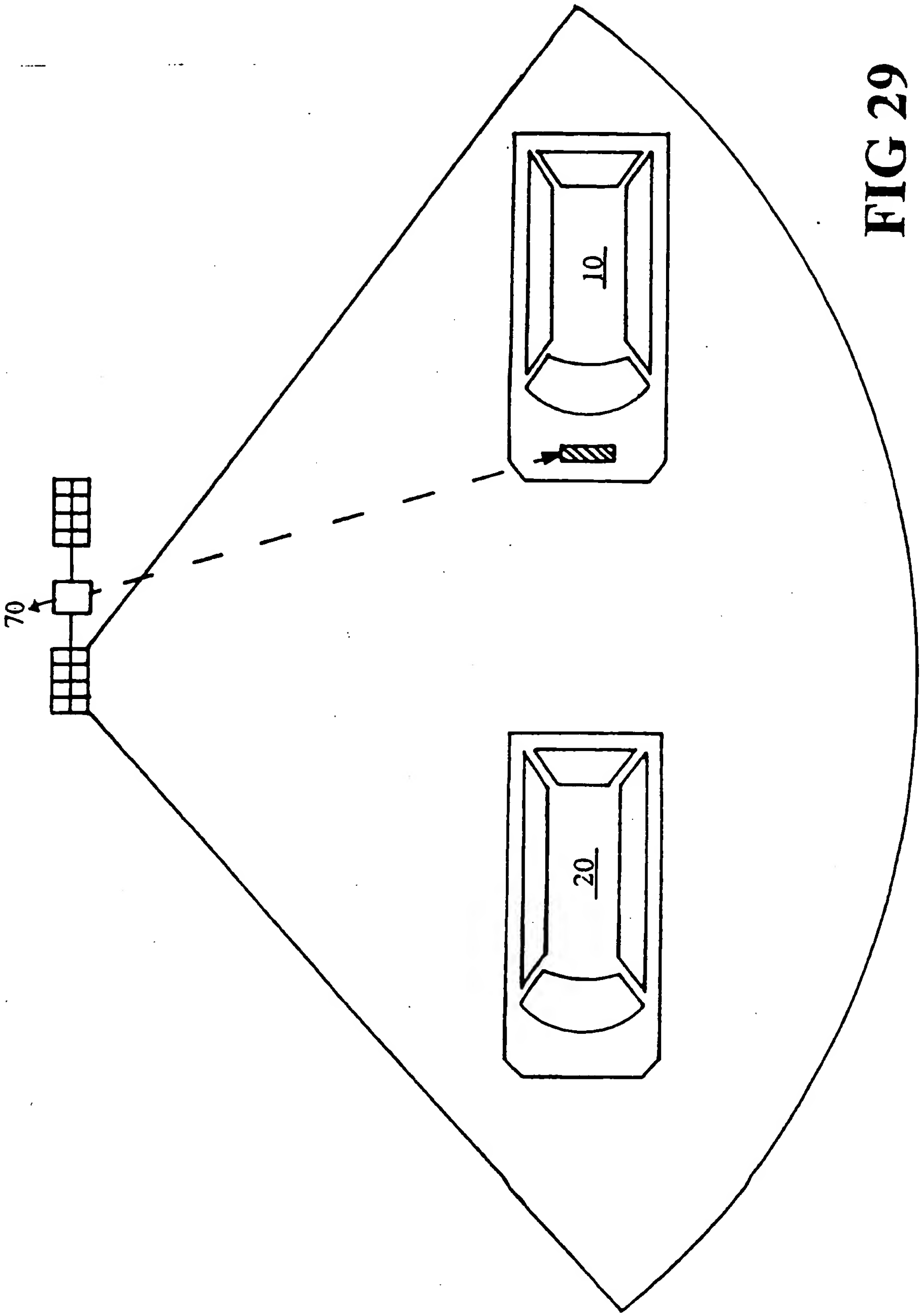

FIG 29

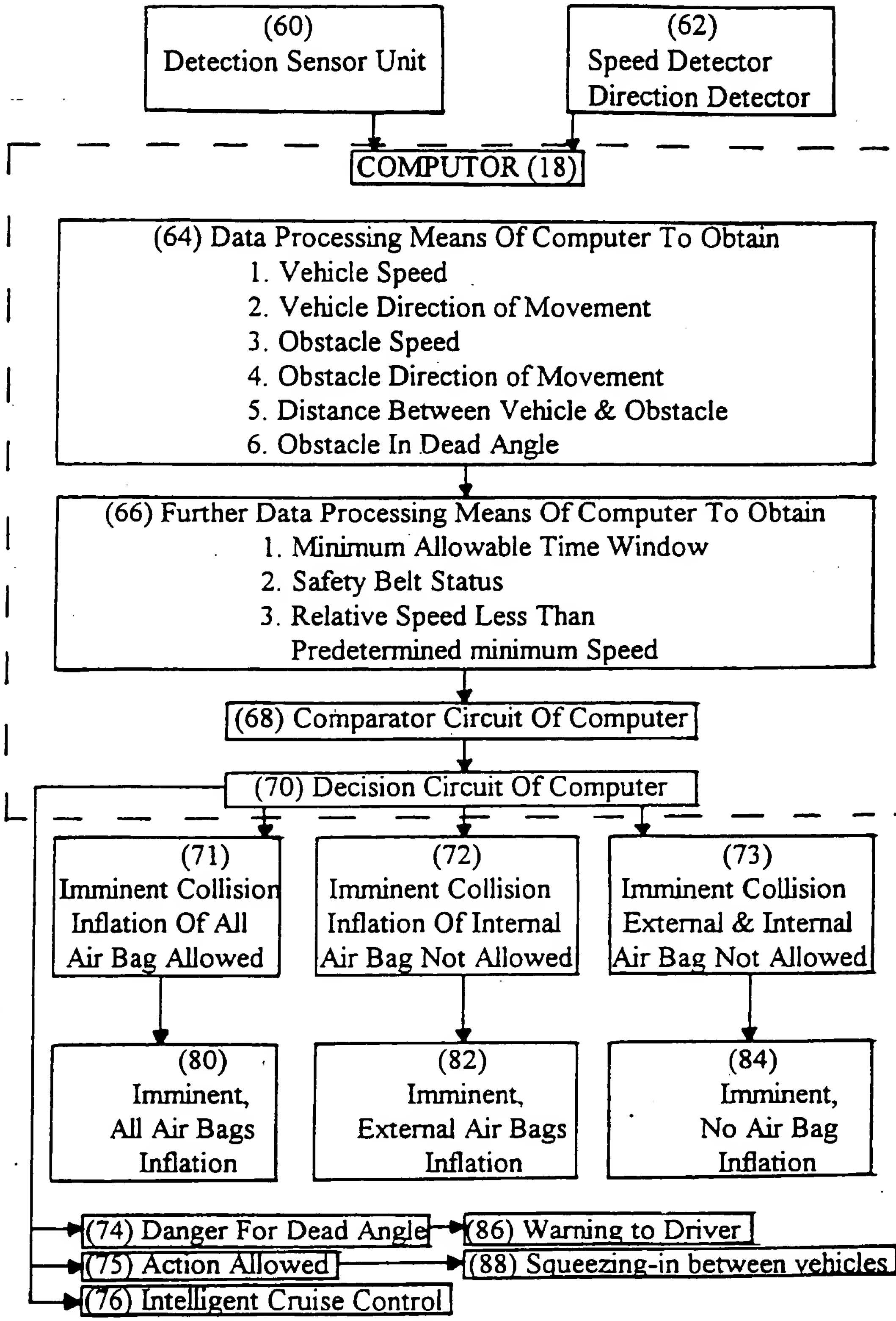
(60)
Detection Sensor Unit
(62)
Speed Detector
Direction Detector
COMPUTOR (18)
(64) Data Processing Means Of Computer To Obtain
1. Vehicle Speed
2. Vehicle Direction of Movement
3. Obstacle Speed
4. Obstacle Direction of Movement
5. Distance Between Vehicle & Obstacle
6. Obstacle In Dead Angle
(66) Further Data Processing Means Of Computer To Obtain
1. Minimum Allowable Time Window
2. Safety Belt Status
3. Relative Speed Less Than
Predetermined minimum Speed
(68) Comparator Circuit Of Computer
(70) Decision Circuit Of Computer
(71)
Imminent Collision
Inflation Of All
Air Bag Allowed
(72)
Imminent Collision
Inflation Of Internal
Air Bag Not Allowed
(73)
Imminent Collision
External & Internal
Air Bag Not Allowed
(80)
Imminent,
All Air Bags
Inflation
(82)
Imminent,
External Air Bags
Inflation
(84)
Imminent,
No Air Bag
Inflation
(74) Danger For Dead Angle
(86) Warning to Driver
(75) Action Allowed
(88) Squeezing-in between vehicles
(76) Intelligent Cruise Control

FIG 30

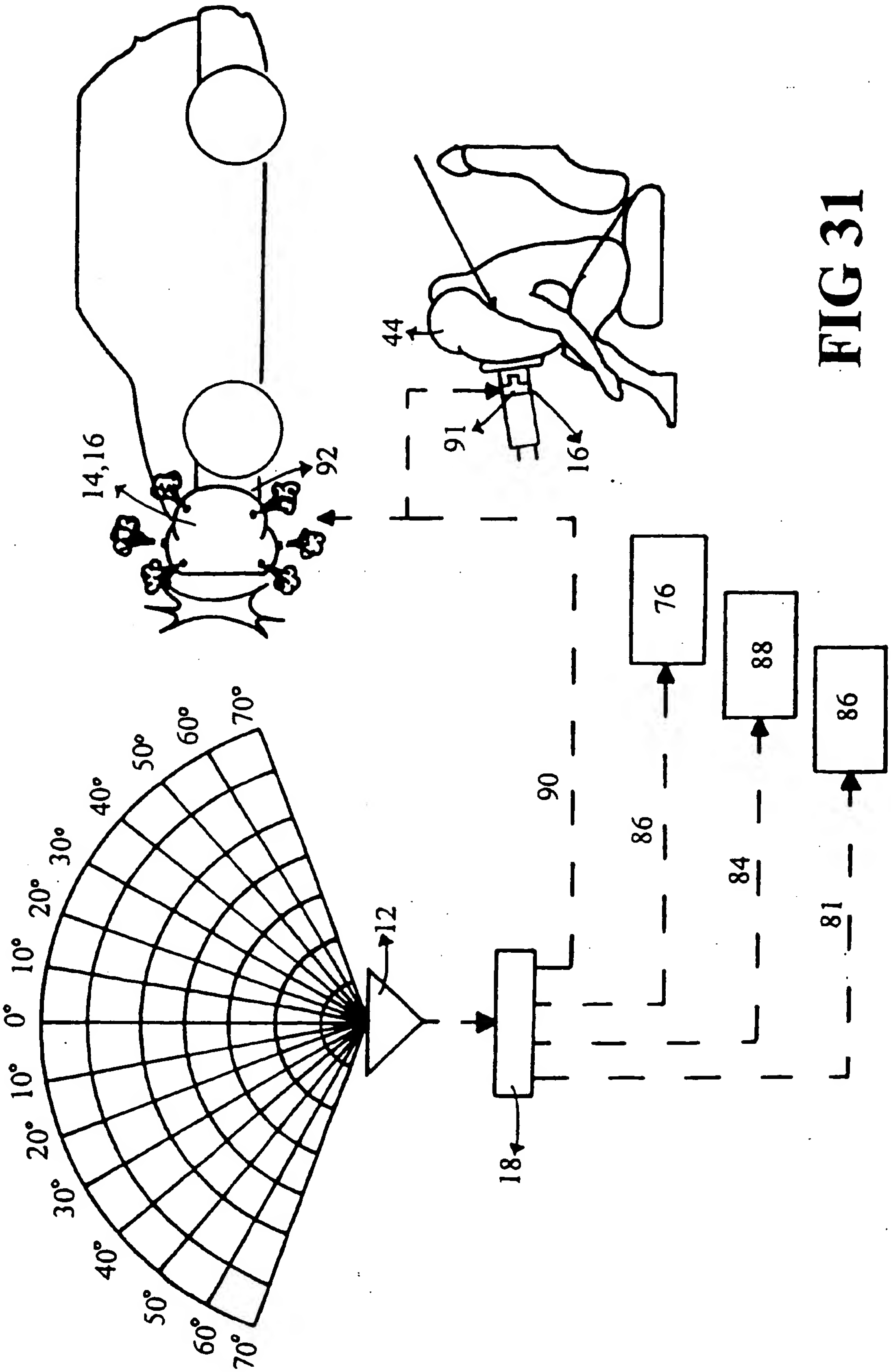

FIG 31

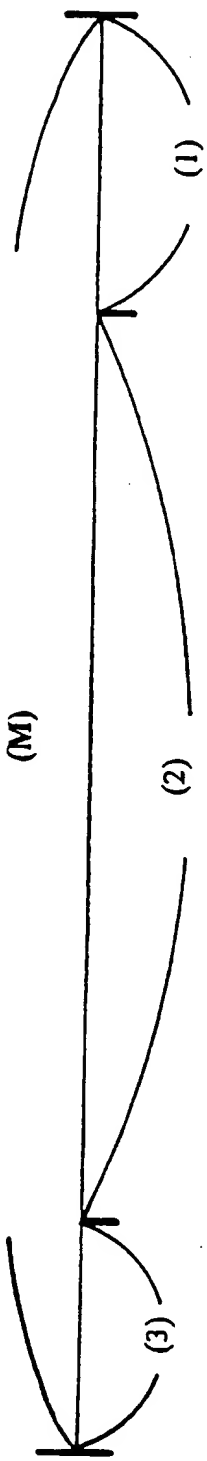

FIG 32A

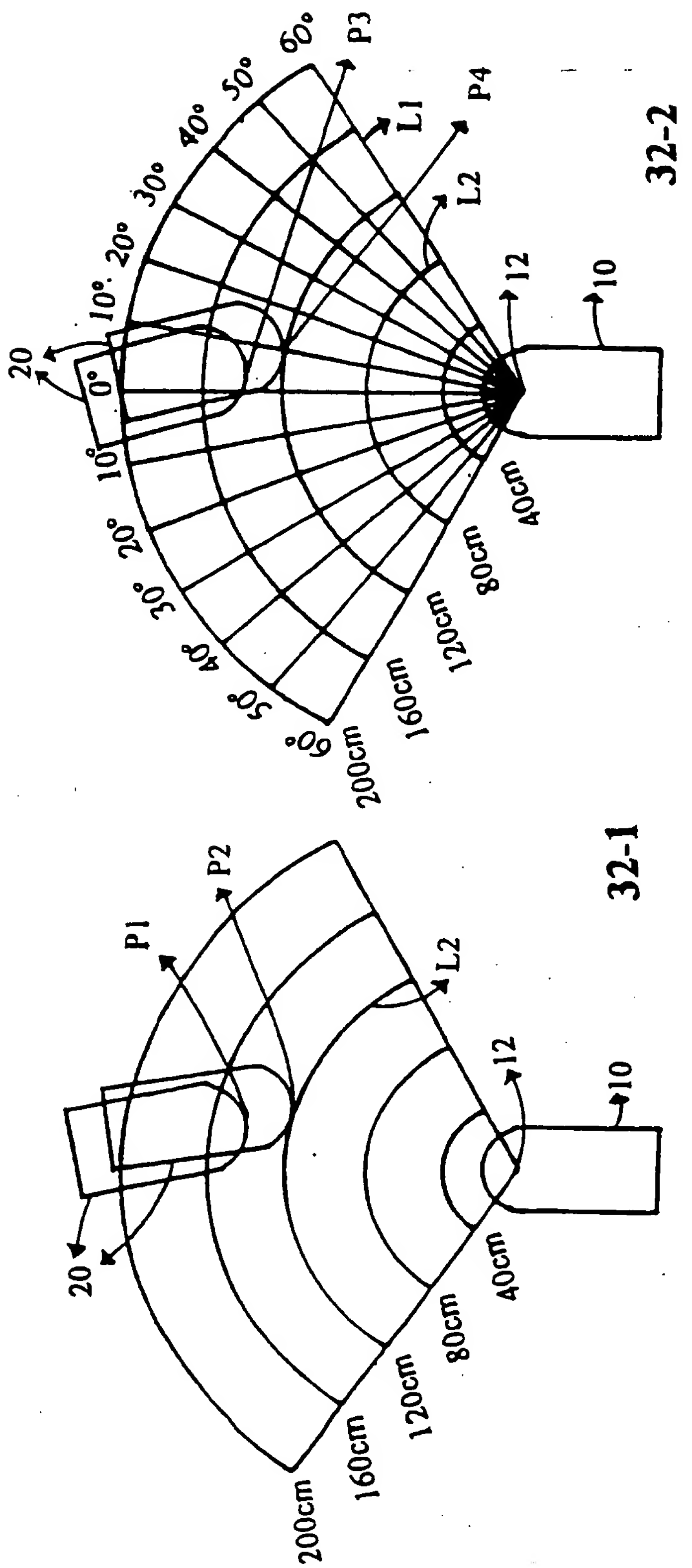

FIG 32

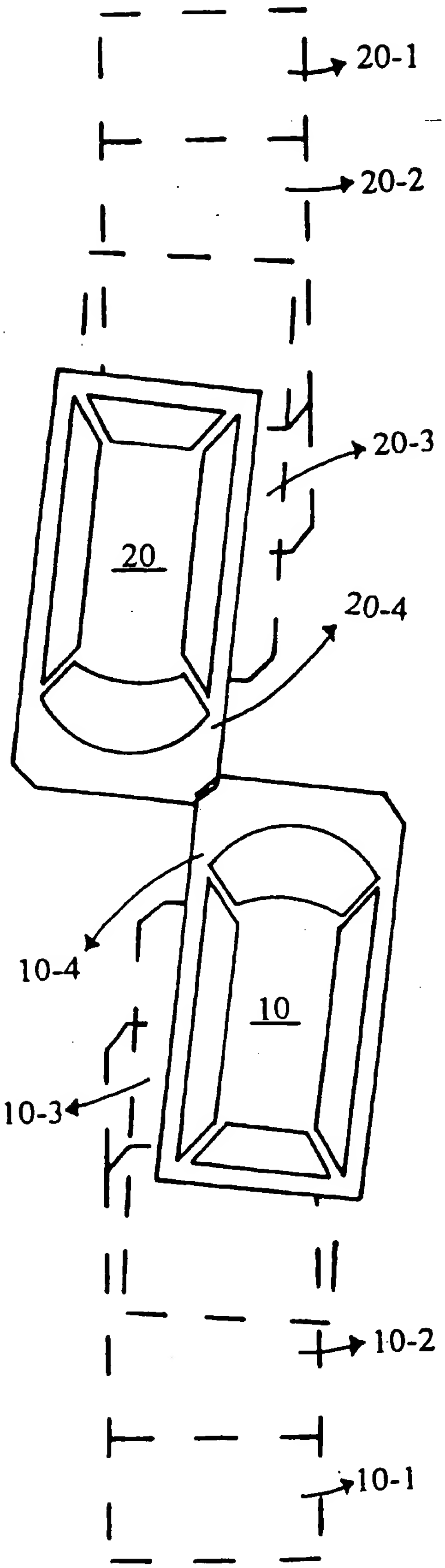

FIG 33

SYSTEM FOR MINIMIZING AUTOMOBILE COLLISION DAMAGE AND PERSONAL INJURY

This application is a continuation in part of U.S. Ser. No. 08/650,869 filed May 20, 1996 now U.S. Pat. No. 5,646,613.

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to a system for minimizing damage to automobiles involved in accidents or collisions and for restricting personal injury in accidents or collisions. In one aspect, the invention relates to a computer processor based system for predicting a collision and deploying airbags for protection of the occupants and the roadway vehicle just prior to the impact. More particularly, the present invention relates to a system for monitoring the speed and direction of the roadway vehicle, the speed, direction and distance of other obstacles in relationship to the roadway vehicle, for affording intelligent cruise control, warning to the operator, and for deploying of air bags prior to the collision to restrict the movement of the occupants and to absorb the impact of the obstacle colliding with the roadway vehicle. Another aspect is the monitoring of vehicles adjacent to the roadway vehicle to advise the driver of the roadway vehicle when it is safe to change lanes.

2. Description of the Prior Art

Various airbags have been adopted to protect the passengers of a vehicle from injuries resulting from collisions. These air bags have been the steering wheel airbag to protect the driver and the passenger side air bag to protect the passenger. However, these air bags have been found to be the cause for some serious injuries and death to children and short adults. Further there have not been proposals to reduce the cost of repair or replacement of an automobile involved in a collision. Numerous attempts in the art from bumper construction to air bags, to vehicular control and warning systems have come about to protect the occupants of the vehicle. Despite this regard for reducing human danger, in most collisions the damage to the vehicle is unmitigated, creating substantial costs for repair or replacement. Also, the present air bags that deploy upon impact of the roadway vehicle with an obstacle have been found to be the contributing factor in injury and death during accident.

A plethora of patents exemplify various automotive devices known for human protection. Early designs to protect the automobile include: Collision Avoidance System published in the Fortune magazine dated Dec. 11, 1995 currently developed by TRW, describing that a computer based system that adjusts the throttle and the brake to automatically maintain a safe following distance. British Patent Specification No. 550,194 describes a bumper for motor vehicles having a concave cross section and an outer cover within which is located an elastic member having a valve to inflate the pneumatic bumper to provide a protective air cushion throughout the entire surface of the bumper. German patent No. 2,020,360 issued Nov. 11, 1971 discloses a vehicle with bladders that are inflatable at will by the driver of the vehicle by electrical, hydraulic, pneumatic or mechanical means, or there are automatic means provided which initiate inflation of the bladders themselves. For example, sensors can be provided which, e.g., address the distance of the vehicle from a hazard under reverse extrapolation from the approach speed towards this hazard. There may also be provided sensors which address a predetermined deceleration of the vehicle air bags surrounding the

vehicle to protect the vehicle, which air bags are inflated when the vehicle is approaching an object and the distance to the object is diminishing and a collision is likely. U.S. Pat. No. 4,215,878, issued Aug. 5, 1980 to Hirbod, discloses an internal air bag deployment system for protecting automobile occupants from injury during an accident. U.S. Pat. No. 4,528,563, issued Jul. 9, 1985 to Takeuchi, discloses an obstruction sensing system to provide an alarm when an obstruction is within a warning area. U.S. Pat. No. 4,694,295, issued Sep. 15, 1987 to Miller et al., discloses a system for warning a driver if another vehicle is located in the blind spot of the mirrors and delivers a warning or provides the actual distance in feet between the vehicle and operators vehicle. U.S. Pat. No. 5,119,901, issued Jun. 9, 1992 to Buie, discloses a vehicle air bag system having switches for triggering the air bags when the bumper is moved and a distance measuring system for generating an alarm signal when a radar ranging device detects tile distance between the vehicle and other vehicles to be in a potentially dangerous condition. U.S. Pat. No. 5,347,273, issued Sep. 13, 1994 to Katiraie, discloses an ultrasonic detection system for sensing an obstacle and measuring the distance to that obstacle and generating an alarm or activating an air bag when the vehicle is within a dangerous distance to another vehicle. U.S. Pat. No. 5,106,137, issued Apr. 21, 1992 to Curtis, discloses an improved vehicle bumper having, internally of the bumper shell, an air bag for providing additional energy absorption upon impact. U.S. Pat. No. 5,165,497, issued Nov. 24, 1992 to Chi, discloses a system for controlling driving distances. U.S. Pat. No. 5,166,881, issued Nov. 24, 1992 to Akasu, discloses a control apparatus for maintaining a set distance between a vehicle and a leading vehicle. U.S. Pat. No. 5,202,742, issued Apr. 13, 1993 to Frank et al., discloses a vehicle guidance system utilizing laser radar. U.S. Pat. No. 5,209,519, issued May 11, 1993 to Shiga et al., discloses an air bag for protecting the occupants of a vehicle upon impact. U.S. Pat. No. 5,314,037, issued May 24, 1994 to Shaw et al., discloses an automobile collision avoidance system that uses a laser radar and microprocessor for anticipating a collision and warning the driver of the possibility of the accident. Additionally, this patent discloses the control of vehicular functions such as braking. U.S. Pat. No. 5,324,072, issued Jun. 28, 1994 to Olson et al., discloses an air bag for protecting the occupant of an automobile from broadside injury by deploying the air bag from the internal side of the automobile. U.S. Pat. No. 5,332,057, issued Jul. 26, 1994 to Butsuen et al., discloses an automatic vehicular control system for altering the direction and/or speed, ultimately avoiding contact. U.S. Pat. No. 5,357,438, issued Oct. 18, 1994 to Davidian, discloses an anti-collision system for automobiles using a multiplicity of sensors and a computer processor for predicting an accident, and subsequently warming the vehicle operator of the possible danger. U.S. Pat. No. 5,400,864, issued Mar. 28, 1995 to Winner et al., discloses a system and method for controlling vehicle speed by maintaining a set safe distance from a preceding vehicle. U.S. Pat. No. 5,461,357, issued Oct. 24, 1995 to Yoshioka et al., discloses an obstacle detection device for a vehicle, which upon obstacle detection, subsequently controls vehicular functions and emits an alarm warning the operator of the imminent danger. Canadian patent doc. No. 923,604, published Mar. 27, 1973 by Lalone et al., discloses a vehicle anti-collision automatic control system for predicting a collision between two vehicles and causing the vehicle to be slowed or stopped, avoiding a collision. Despite the abundance of such devices, none of the above inventions and patents, taken either singly or in combination, is seen to describe the instant invention as claimed.

SUMMARY OF THE INVENTION

Over the years since the inception of the automobile, many features have been added to enhance its functionality and appearance. For passenger safety, these enhancements range from front seat lap belts to real seat full shoulder harnesses, and from reinforced frame beams to internal air bags. These enhancements have been instituted while maintaining an appealing aesthetic character to the automobile. For example, body side moldings and matching bumpers protect the vehicle and occupants while providing an attractive appearance to the onlooker. For this reason, maintaining the attractiveness is important. The importance resides in the fact that most of the value of a vehicle is not found in its performance, but rather in its appearance. Unfortunately, all of the safety features that have been incorporated in today's modern vehicles do not always restrict the occupants against injury and do not protect the physical appearance of those parts of the vehicle exposed during a collision. These parts, apart from the volatile parts of the vehicle (namely, the engine, gas tank, etc.) need some protection to avoid costly repair and replacement of the assets governing the value of the vehicle in the event of a collision with another obstacle.

The present invention relates to a roadway vehicle equipped with a computer based system for predicting a collision and deploying air bags at an appropriate time for reducing the amount of damage sustained by the roadway vehicle in an accident and for restricting the amount of injury to occupants. The system includes basically, a detection sensor unit for detecting speed, distance, and direction of other obstacles; a speed detector for detecting speed of the roadway vehicle by speedometer; a direction detector for detecting direction of the roadway vehicle; an energy absorbing inflation unit and a central computer processing unit (CPU).

Accordingly, the invention provides an automobile, roadway vehicle, with a system for reducing the amount of physical damage resulting from collision and for restricting injuries or death to occupants resulting from the deployment of driver and passenger air bags upon impact. It is another object of the invention to provide a system that automatically determines the possibility of an accident and initiates damage reducing actions.

It is a further object of the invention to provide a system that automatically deploys air bags externally of the vehicle in the event of an accident, thereby preventing major damage to the vehicle.

Still another object of the invention to provide a system that automatically deploys air bags or keeps the air bags always deployed, internally of the vehicle bumper in addition to the externally deployed air bags of the vehicle in the event of an accident, thereby preventing major damage to the vehicle.

Further, the invention provides a system that automatically deploys airbags internally of the vehicle prior to an imminent collision to restrict injury or prevent death of the occupants.

Further, due to the cost of repair and replacement of air bags, when the roadway vehicle is within an unavoidable collision distance (equal with the minimal allowable time window), it is another aspect of this invention to have switches to disable the inflation units for the internal air bags when the safety belt is not fastened. Also, another aspect of this invention is to have the relative speed between the two vehicles control inflation of the air bags, e.g.: (1) lower than 5 mph, no air bags inflate, (2) higher than 5 mph, external air bag only inflate, (3) higher than 20 mph, external and internal air bags inflate.

Further, the present invention provides a system that maintains the original aesthetic quality of a vehicle in the event of a collision.

Further, the present invention provides a system of intelligent cruise control, a system for advising the driver of the roadway vehicle when it is safe to change lanes, a warning system for warning the driver of the roadway vehicle when the roadway vehicle is backing up and when any obstacle is existing in the dead angle and a system to deploy air bags to hold occupants in their seats and to deploy air bags external to the vehicle perimeter to cushion and protect the aesthetic appearance of the roadway vehicle in the event of an actual collision.

Still further, the present invention provides a system to monitor the location of the roadway vehicle in relationship to other vehicles and obstacles by utilizing the Global Positioning System (GPS) as the detection sensor unit to detect the relationship the roadway vehicle, its speed and direction, in relationship to the speed, direction and distance from obstacles, including vehicles, to control the onboard energy absorbing inflation devices, intelligent cruise control system, anu warning system, for restricting damage to the roadway vehicle and for restricting injury or death occupants.

These and other features and objects of the present invention will become readily apparent upon future review of the following specification and drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be described with reference to the accompanying drawing wherein:

FIGS. 1 and 2 are perspective views of all automobile equipped with the system of the present invention showing comparison views of external air bags before and after inflation;

FIGS. 3 and 4 are environmental side views of the system of the present invention in states before and after a collision;

FIG. 5 is an enlarged diagrammatic view of a representative air bag as stored in the automobile shown in FIG. 1;

FIGS. 6, 6A and 6B are diagrammatic representations of alternative embodiments of external air bag constructions utilized in accordance with the present invention, with FIG. 6 showing deployed air bags from ports in the vehicle;

FIGS. 7, 8, 9, 10 and 11 are top environmental views of alternative radar arrangements of the present invention;

FIG. 12 is a perspective view of a roadway vehicle equipped with the present invention;

FIG. 13 is a cross-sectional view of the front bumper of the vehicle of FIG. 12 illustrating the closed lids of the bumper housing the folded air bag and inflation unit,

FIG. 14 is a perspective view of the roadway vehicle of FIG. 12 with the air bag in the bumper deployed;

FIG. 15 is a cross-sectional view of the front bumper of the vehicle of FIG. 14;

FIGS. 16 and 17 are a diagrammatic views showing the location of internal and external air bags of the roadway vehicle with the air bags inflated;

FIG. 18 is a diagrammatic view of a seat belt buckle and clasp;

FIG. 19 is a diagrammatic view of a passenger leaning forward of the normal position in a seat to illustrate the shoulder belt and air bag control;

FIG. 20 is a top environmental view of the preferred embodiment of the a·rangement of the air bag and detector locations external to the vehicle;

FIG. 21 is an environmental view illustrating the system predicting collision with other obstacles;

FIG. 22 is a perspective view showing a modular automobile body for returning the deflated and folded air bag to the automobile as shown in FIG. 3 after a collision;

FIG. 23 is a series of views depicting (23-A) the normal position of an occupant in a roadway vehicle, (23-B) the position at the time the CPU determines a collision is imminent and air bag to start to inflate, (23-C) the position just prior to impact, (23–D) the position upon initial impact or collision, and (23–E) the position when the roadway vehicle initially comes to rest after collision;

FIG. 24 is a series of views depicting a child seat in the passenger seat of a roadway vehicle in (24-A) the normal position of the roadway vehicle, (24-B) the position at the time the CPU determines a collision is imminent and air bag starts to inflate, (24-C) the position just prior to impact, (24-D) the position upon initial impact or collision, and (24-E) the position when the roadway vehicle initially comes to rest after collision;

FIG. 25 illustrates diagrammatically the vehicle warning feature of the present system to alert the driver of the roadway vehicle (10) when obstacle (20-1) is in dead angle;

FIG. 26 illustrates diagrammatically the vehicle warning feature of the present system to alert the driver of the roadway vehicle (10) foot something existing behind the vehicle.

FIGS. 27 and 28 illustrate diagrammatically the use of the squeezing-in feature of the present system to aid the merging of the roadway vehicle (10) with vehicles (20) in another lane of traffic; and FIG. 27A illustrated the indication of the squeeze in status;

FIG. 29 is a diagrammatic view of the satellite (70) in place of the radar to monitor the location of the roadway vehicle (10) and other vehicle (20);

FIG. 30 is a block diagram illustration of the typical flow of the system logic for predicting a collision and deploying the air bags;

FIG. 31 is a diagrammatic view of the system of the present invention and its relationship to the systems described in blocks and schematic representation;

FIGS. 32-1 and 32-2 include diagrammatic views of functions of the detection sensor unit and the computer and compares the present invention with conventional devices regarding determination of imminent situation based on speed, distance and direction; and FIG. 32A illustrates the minimum allowable time window (M)).

FIG. 33 illustrates the preceding aspects of the two vehicles (10 and 20) in imminent situation, wherein collision is commonly made on the corner of the vehicle.

Similar reference characters denote corresponding features consistently throughout the attached drawings.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

In the preferred embodiment, a roadway vehicle is equipped with a computer based system for predicting a collision and deploying air bags at an appropriate time for reducing the amount of damage sustained by the vehicle in the accident and reducing the risk of bodily injury or death to the occupants. The system includes basically, a detection sensor unit, speed detector, direction detector, at least one energy absorbing inflation unit and a central computer processing unit (CPU).

The detection sensor unit can be of any known type that is radiant energy detector including infrared, radar, laser radar, laser, and microwave, that is sonic detector including ultrasonic and acoustic detection devices, wherein laser radar is optionally used because of the more narrow beam width and angular resolution, as the laser radar importantly gives more specific and precise information of detected vehicle's or obstacle's direction, distance, size and relative speed. One such system may include a radar detection device transmitting and receiving signals at a rate in the range of 1 to 1,000,000,000 samples per second. The data obtained by detection sensor unit (hereinafter, radar) is processed by a computer to determine the time of an imminent collision.

The speed detector of the preferred embodiment provides information to the CPU concerning the speed and other vital information concerning the roadway vehicle. This information gives the CPU the instantaneous parameters of the operation of the vehicle allowing the CPU to predict the time an impact will occur.

The energy absorbing inflation unit, typically an air bag unit, responds to a control signal generated by the CPU. The unit has a volume of inflation gas contained in an inflation device (hereinafter inflator). The inflator has an electronically controlled valve that is activated by the CPU, releasing the inflation gas into the air bag. The air bag forms an energy absorbing barrier between the roadway vehicle and the object of the collision to reduce impact. The air bag uses high pressure release valves to divert and dissipate the absorbed energy into the atmosphere. The internal energy absorbing unit is also an air bag, of the type that is standard in the industry, but differs from that of the present invention in that the sensor to release the inflation gas into the air bag is activated by the CPU.

A preferred embodiment of the present invention utilizes a plurality of energy absorbing inflation units externally and internally of the roadway vehicle.

A CPU capable of receiving, and processing input information, and ultimately generating an output signal initiating action is used. Such CPUs are conventional in the art. The CPU of the present invention, through simple known algorithms, with speed, distance, and directional data, can predict when an accident or collision is imminent. The CPU of the present invention, once the prediction has been made, further assesses the time necessary to maximize the protective effect of inflation and generates a control signal to the inflation unit. The time deemed necessary is generally referred to as a minimum allowable time window.

Another aspect of the present invention is that the CPU calculates anticipated collision point on the basis of speed, distance, direction and predetermined minimum allowable time window. The minimum allowable time window of the present invention is to be used for inflating air bags only when it is an unavoidable collision situation and represents the time period up to a collision during which it is impossible for a driver to take action to evade a collision. Note that the purpose of the minimum allowable time window used in Shaw's invention (U.S. Pat. No. 5,314,037 issued May 24, 1994) is to evade a collision and represents the time period prior to a collision during which it is possible for the driver to take action to evade a collision.

A CPU of the conventional devices as in 32-1 of FIG. 32, is capable of receiving information on speed and distance from the roadway vehicle (10) to point 21, then to point 22 which is 120 cm distance from roadway vehicle 10 and processing input information and ultimately generating an output signal initiating action to anticipate two different situations; (1) colliding case and (2) collision avoiding case.

However the CPU of the present invention as in 32-2 of FIG. 32, through simple known algorithms, given the necessary speed, distance of obstacle (20) moving from point 23 to point 24, 120 cm from roadway vehicle (10), and an assumed parabola made by extending the path of vehicle (20) from point 23 (145 cm×4 degree oil right) to point 24 (120 cm ×10 degree on right), can predict a collision point on the basis of the predetermined minimum allowable time window (e.g. 0.2 second), only predicts whether a collision is imminent or not. By doing so, if the assumed parabola meets the roadway vehicle (10), a collision definitely arises at the point meeting with the roadway vehicle (10), and so the CPU orders the air bag to inflate before impact.

Once a collision becomes imminent, unavoidable and inescapable, the CPU determines the time of impact according to the minimum allowable time window and sends a control signal to the inflation unit. The control signal causes the air bag or bags to inflate during the minimum allowable time and the inflated air bag absorbs the energies associated with the impact power. These energies generally include kinetic, momentum and inertial energies among others. The inflation of the external air bags will reduce the impact power of driving machineries into the compartment of driver and passenger . Thus, upon impact, the occupants are carried forward against an inflated internal air bag instead of against an inflating internal air bag which because of the speed of inflation can exert a devastating blow against an accelerating person, object or an infant seat, e.g. moving in the direction of the inflating air bag.

Referring to FIGS. 1 and 2 a roadway vehicle 10 is equipped with the system of the present invention described herein. The system does not interfere with the current level of aesthetic qualities associated with the modern vehicle of today. The exterior of the vehicle 10 ~~has~~ bumpers 10A supporting radar ports 12A and air bag ports 14A. When activated, air bag 14 is inflated through the air bag port 14A, forming an impact buffer between the vehicle 10 and the object of the collision. Mounted in the door panels 46 of vehicle 10 are air bag ports 44A preventing damage to the side of vehicle 10 in a manner similar to that previously described. Greater detail of the system is discussed below and shown in FIGS. 3 and 4, 7 through 11 and 20.

In FIG. 3 the roadway vehicle 10 is in typical traffic road flow. Vehicle 10 is preceded by leading vehicle 20, and succeeded by trailing vehicle 30. The convoy depicted is commonly seen on any roadway, and the speed of each vehicle should be at the appropriate speed limit. Unfortunately, conditions arise to cause disruption in the uniform flow of traffic. For example, while traveling at a high speed leading vehicle 20 approaches an unexpected road hazard, such as a major pothole. Leading vehicle 20 attempts to slow down or stop. Unfortunately, the vehicles 10 and 30 fail to anticipate the danger ahead of leading vehicle 20. Vehicle 10, being equipped with the system of the present invention, has a CPU 18 that constantly monitors the traveling parameters of the vehicle 10 from the dashboard 22 via dashboard link 24. The dashboard 22 including speed detector and direction detector provides information of the speed and direction of the vehicle 10. Speed information may be provided by a speedometer, for example, and directional information may be obtainable from a radar unit mounted at various locations in vehicle 10. The CPU 18 also receives input signals from radar 12 via data lines 28. The radar 12 transmits and receives information concerning the leading 20 and trailing 30 vehicles via the transmitted and reflected signals 32. The signals 32 are sampled by the CPU 18 at a high rate in order to ensure the minimum allowable time (collision unavoidable time) window is satisfactorily set. The signals 32 provide the CPU 18 with information relating to the relative distance between vehicle 10 and both leading 20 and trailing 30 vehicles. Also, signals 32 provide the CPU 18 with information relating to the speeds and moving directions of vehicles 20 and 30. With this information the CPU 18 calculates the changes in distance, speed and direction of vehicles 20 and 30 with relationship to vehicle 10. The CPU 18 is programmed to acknowledge abrupt changes as to potential indications of an impending collision. As leading vehicle 20 suddenly changes speed by braking, radar 12 aboard vehicle 10 detects the change and submits the information to CPU 18. Likewise, as vehicle 10 begins to brake in response to the braking of vehicle 20, radar 12 detects a relative increase in speed from trailing vehicle 30. CPU 18 alerts the operator of vehicle 10 that a collision may occur involving either or both leading vehicle 20 and trailing vehicle 30. CPU 18 also calculates a collision unavoidable distance, determines the apparent time of imminent collision on the basis of the established minimum allowable time window, and generates a control signal. When the collision becomes imminent, unavoidable and inescapable, the control signal is sent from CPU 18 to inflation unit 16 via control lines 26. The inflation gas fills air bags 14 and the air bags 14 are deployed externally of the bumper, after which the inevitable collision occurs as in FIG. 4. By the impact pressure the gas is released from the air bags through valves. In addition, supported internally of the bumpers 10A are several auxiliary air bags 14B. Auxiliary air bags 14B provide impact absorption to the vehicle 10 and bumpers 10A. The auxiliary air bags 14B remain inflated at all times, giving the bumpers 10A an internal buffer for low speed impacts (e.g., 5 mph collision) at which the CPU would not send the control signal to the air bags 14. The air bags 14 provide an energy absorbing buffer between the colliding vehicles 20, 10 and 30. As illustrated in FIG. 5, all inflation unit assembly, including inflation unit 16 and air bag 14, is stored in the vehicle. Inflation unit 16 contains a volume of compressed gas or chemicals. The air bag 14 is shown in a deflated and folded position adjacent to the inflation unit 16. The air bags 14 are illustrated in inflated condition at the front of the vehicle 10 in FIG. 6. As illustrated in FIGS. 6A and 6B, to help absorb the collision energies, air bags 14 convert the absorbed energies into air or gas movement, and the air or gas is released through high pressure release ports 34 to discharge the energy into the atmosphere. Thus, air bag 14 helps maintain the aesthetic quality of the bumper shape of the vehicle 10. Air bag 14 is shown as having multiple compartments, for example other compartment 36 and inner compartment 38, which compartments' operation is more clearly shown in FIGS. 6A and 6B as briefly mentioned above. As seen in FIG. 6A, the outer compartment 36 surrounds inner compartment 38. Each of the outer 36 and inner 38 compartments has a plurality of the high pressure release polls 34 for diverting the impact power to the atmosphere. Alternatively, as seen in FIG. 6B, the inner compartment 38 is completely enclosed internally of the outer compartment 36. The inner compartment 38 has a plurality of high pressure release ports 34 that release the gas into the outer compartment 36. The outer compartment 36 ~~also has a~~ plurality of high pressure release ports 34 that release the gas into the atmosphere. The construction of the high pressure release ports may be accomplished using any of numerous conventional means known in the art, for example, the ports 34 seen in the FIGS. 6A and 6B. Likewise, the ports 34 may include a pneumatic type valve, such that upon impact a valve stem extends from each port

through which the internal pressure at impact is forced. It is also conceived that simple a stopper type pop out in each port may be provided. However, the stopper should be permanently tethered to the air bag 14 as a projectile safeguard.

FIGS. 7–11 illustrate various arrangements for location of the radar units 12 on vehicle 10. FIG. 7 shows a vehicle having an omni-directional radar unit emitting a 360 degree radial beam 40A and receiving its corresponding reflected beam. The radial beam 40A may be emitted in many known ways, such as by rotating radar 12. FIG. 8 illustrates a plurality of radars 12 surrounding the perimeter of the vehicle 10, each radar having an inspection region shown by beams 40B (which may overlap increasing continuous perimeter coverage). FIG. 9 illustrates an arrangement of four radars 12 inspecting quadrant regions by beams 40C. FIGS. 10 and 11 illustrate the forward and rearward detection arrangement of the preferred embodiment, radar 12 located in the front of the vehicle 10 is coupled with the steering mechanism of vehicle 10 so that as the steering wheel turns, the radar unit 12 is correspondingly turned to maintain its beam in a direction generally parallel with the direction of the front wheel of the roadway vehicle. This results in the forward beam 40D inspecting the vicinity of the turn into which the vehicle 10 embarks. Beam 40E maintains a rearward inspection, monitoring abrupt changes in distances of vehicles approaching vehicle 10.

FIGS. 12 and 13 illustrate an alternative where the air bags are folded behind ports, lids or doors in the vehicle body which open when an air bag 14 is deployed. As illustrated in FIG. 13, the air bag 14 is folded behind the doors 42 and 43 in the vehicle bumper 10A, inflation unit 16 is protected from impact by steel frame 15 and also protected from impact by buffer 13 which is connected to internal body frame together with steel frame 15 when air bag inflation is not required due to lower speed impact. The doors 42 and 43 are shown as moving upward and downward respectively, as in FIG. 15 to allow the air bag 14 to fully inflate as best shown in FIG. 14. The air bag 14 is deployed by the inflation unit 16.

A roadway vehicle equipped with the computer based system and the CPU for predicting a collision, may also protect the occupants of the roadway vehicle by deploying internal air bags at an appropriate time prior to the impact to restrict, or substantially reduce the risk of bodily injury or death to the occupants. The interior system includes basically the radar 12, dashboard (the speed detector and direction detector) 22 in FIGS. 3 & 4, at least one energy absorbing inflation unit 44 in FIGS. 16 & 17 and the central computer processing unit (CPU) 18.

FIGS. 16 and 17 show the locations of the internal air bags 44, including side air bag, knee air bag, rear seat air bag, ceiling air bag, driver and passenger airbags. Inflation of these air bags, just prior to collision, provides cushions for the occupants to restrict the travel and force of the impact with the obstacle. On the contrary, the air bag in prior arts is deployed upon impact by which the occupants are being thrown causing a second collision often resulting in abrasions, broken members and in death.

FIG. 18 shows a seat belt buckle set which is to be clasped in order to prevent the unnecessary deployment of the internal air bags prior to a collision. To hold the internal air bag form being deployed when a seat is not occupied, the two methods are proposed for being applied: (1) the buckle 45 is directly connected with the ignition switch of the inflation unit 16 shown in FIGS. 5 and 6, wherein the buckle is not connected with the CPU, (2) the buckle 45 is connected with the CPU only, wherein if the buckle 45 is not clasped, the circuit in the control line 26 shown in FIGS. 3 and 4 between the CPU and the inflation unit 16 shown in FIG. 5 is broken as the CPU doesn't make an air bag inflation order. This would prevent the costly operation associated with the unnecessary deployment of the air bag. However, the inflation unit is standard in the industry and has a volume of inflation gas to be released into the associated air bag to protect the passenger. In the present invention the system will deploy the air bag in the minimum allowable time window upon the CPU determining an imminent collision and sending signals to the inflation unit. Thus, the passengers are still in the normal riding position when the air bags deploy prior to a real collision, and immediately an impact occurs carrying the passenger in the direction of the impact and against an already inflated air bag.

FIG. 19 illustrates a driver or a passenger of a roadway vehicle bending forward in the seat to get something from the floor of the vehicle or from the glove compartment, wherein if the air bag were to inflate by the system of the conventional devices sensing an imminent collision at that moment, the person will have to encounter a blow of 200 mph from the inflating air bag. To avoid such situation, the present invention includes a system to control the inflation unit 16 shown in FIG. 5 by a switch installed on the roller 82. A large person will normally require more length of the seat belt and the shoulder strap. When the belt is stretched out more than a normal allowable amount, the switch of the roller 82 is opened to disconnect the roller from the CPU to disable the air bags 44 and an audio and/or visual alarm is activated. When the roller 82 starts to role by pulling it out, the switch puts the air bag function to the normal position. When the passenger returns to the normal position from the bent position, the alarm stops and the roller switch and the CPU for the air bag system return to normal.

FIG. 20 illustrates the preferred position and arrangement for the inflation units 16 and external air bags 14 which protect the vehicle and the occupants from damage and injury. The roadway vehicle 10 has a plurality of the inflation units 16 and associated air bags 14 positioned around the vehicle. The CPU 18 is also operable to selectively control each inflation device and minimizes damage to the vehicle regardless of the direction of the imminent collision.

FIG. 22 shows an exemplary view of the interior system of the vehicle 10. The vehicle 10 of FIG. 22 has a modular characteristic, in that the bumpers 10A and door panels 46 are supported on rails 60. These rails 60 allow the bumpers 10A and door panels 46 to slide out and away from the vehicle 10, like drawers. Once in the open position, the deflated and refolded air bags are replaced internally of the vehicle and the bumpers 10A and door panels are returned to the vehicle. Since the amount of damage would be minimal, even at higher velocities, the aesthetic quality of vehicle 10 is preserved. It should be noted that one aspect of the invention is to reduce the physical damage of the vehicle although the invention also protects the occupants of the vehicle from extreme injury created by the impact force, due to the impact being greatly reduced by the system of the present invention. After deployment the system would simply require recharge of the compressed gas in inflation unit 16 and upon deflation, refolding and repositioning of the air bags 14 in the vehicle 10. Additionally, the invention serves to minimize damage to other non-moving vehicles or obstacles. For example, as best seen in FIG. 21, the radar unit 12 functions to detect pedestrians 50, animals 52,

inanimate objects (such as balls 54, pylons, cones, flags, barricades 56, etc), and plants or trees 58. In addition, the system may detect walls, guardrails and utility poles.

FIGS. 23 and 24 disclose various views of the roadway vehicle with the passengers. CPU sends a signal to deploy the air bags and the air bags are deployed. Upon a collision, the movement of the vehicle and passengers associated with the impact is made against the air bags. The internal air bags are selectively inflated according to the location at which the collision occurs. In FIG. 23 several views depict the operation of the present invention.

First, view 23-A in FIG. 23 shows vehicle and occupant in the normal position. In view 23-B, it shows the CPU has signaled that a collision is imminent and the inflation units 16 are triggered and the air bags 14 and 44 are being deployed. The air bags in view 23-C are fully deployed. In view 23-D, collision has occurred and the occupant is thrown against the inflated air bags and the external air bag has made contact with an obstacle abruptly beginning deceleration of the roadway vehicle, and the view 23-E illustrates the roadway vehicle to have stopped. FIG. 24 depicts in several views the sequence with a child in the next seat to the driver. The child is protected by the seat belts in the seat in view 24-A. In view 24-B, CPU has signaled that a collision is imminent and the inflation unit 16 is triggered and the air bags 14 and 44 are being deployed. In view 24-C, the air bags are fully deployed and the collision occurs instantaneously. In view 24-D, the collision has occurred, and the child seat and infant are moved toward the inflated air bags against the strain of the seat belts as indicated by the arrow. The external air bag has made contact with the obstacle abruptly beginning deceleration of the roadway vehicle. In view 24-E, the roadway vehicle has stopped and the child seat hits against the cushion of the air bag.

FIG. 25 illustrates vehicles equipped with the system of the present invention moving along a multi-lane roadway. So often a driver has blind spots and cannot see vehicles that are adjacent to the roadway vehicle 10 and the system of the present invention can be equipped with a warning system to alert the driver to the presence of adjacent vehicles 20-1 and 20-2. Such warning can be visual, light or other signal, audio such as a sound from a buzzer, or a digital readout giving speed and location of the adjacent vehicle. Such information is also given when the roadway vehicle 10 backs up as indicated in FIG. 26. A small object 50 in the rear of the vehicle 10 shown in FIG. 26 will be picked up by the system and a warning signal will be given to the driver of the roadway vehicle 10.

size of determined

FIG. 27 illustrates diagrammatically the squeeze-in system which can be used for the situation that the driver of vehicle 10 desires to make a lane change to the adjacent lane. When vehicle 10 is going to change its lane to the left, the CPU mounted on vehicle 10 calculates on the basis of the information received from the radar and informs the driver of the current status. If speed of vehicle 10 is 20 mph more than that of vehicle 20, the sign given by the CPU to the driver of vehicle 10 will indicate as -20 mph. On the contrary, if speed of vehicle 20 is 20 mph more than that of vehicle 10, it will indicate as +120 mph as seen in FIG. 27A on the appropriate place such as mirrors (1), corners of the front window (2), surface of the dashboard (3) and etc. Therefore, the (+) sign indicates that the speed of vehicle 10 relative to vehicle 20 is sufficient to allow vehicle 10 to change lanes. Using the system of squeeze-in will help the driver make an easy decision as to whether to change lanes or not.

FIG. 28 illustrates another aspect of the present invention using the squeeze-in system. The system informs the driver of vehicle 10 of the speed of vehicle 20 approaching the intersection. It is not appropriate to move into the intersection when radar unit detects the approaching vehicle 20 on the right, and then CPU provides the driver of the vehicle 10 with the speed of vehicle 20 to help for his decision on turning into the intersection.

FIG. 29 diagrammatically illustrates the system according to the present invention, wherein satellite 70 affords signals of the location of vehicle 10 and the location of obstacle 20 to the CPU mounted on vehicle 10. The signal from the satellite is more accurate concerning the location of obstacles.

FIG. 30 shows a block diagram which provides a complete overview of the functional operation of the system disclosed herein. Block 60 for detection sensor unit, represents the radar 12. Block 62 for speed detector and direction detector disclosing information concerning the roadway vehicle 10 transmitted to CPU. The CPU 18 is shown incorporating the various processing sequences. Block 64 receives the information from block 60 and 62, and processes the information into usable data for the CPU 18. Block 66 gathers additional information to be used in determining whether to inflate the internal air bags, for prediction of collision point, for establishment of collision unavoidable distance on the basis of the minimum allowable time window, for determination of safety belt status whether fastened or not, and for determination of the relative speed between the two vehicles to be less than the predetermined minimum speed prestored in the CPU. Block 68 represents the means to continuously compare information provided by Block 64 and Block 66. The output of block 68 is sent to block 70. Block 70 of the CPU 18 examines the output of block 68 and the result of which comes to one of the six sections; 71 is imminent situation—all air bags to inflate in Block 80, 72 is imminent situation—only external air bag to inflate against the predicted collision in Block 82, 73 is imminent situation but not much damage—no air bags to inflate in Block 84 in which case the collision would result in inexpensive damage or injury in comparison with the cost of repair or replacement of an air bag. 74 is for dangerous situation for an obstacle being found in dead angle and warning is given to driver in Block 86, 75 is for vehicle's action to be allowed when trying to change the lane to the adjacent one and the roadway vehicle squeezes into the adjacent lane in Block 88, 76 is for initiating the intelligent cruise control to be made by the CPU 18. When Block 70 comes to an imminent situation, the CPU 18 selects one of the 6 situations and renders a proper action to be taken.

FIG. 31 diagrammatically illustrates how the present system operates in conjunction with other safety systems. Each radar 12 scans the area to the right, left and front of the unit over an included angle of the radar 12 and transmits to the CPU 18 speed, direction and distance data of any obstacle in the ranges of distance in meters from the unit. The information is continually fed to the CPU 18 and the CPU 18 then generates control signals 81 to the danger warning system 86 to alert the driver of the roadway vehicle of the presence of other vehicles or objects in blind spots (dead angle) on either side and behind the vehicle and provides a warning signal on the probable danger. The CPU 18 generates control signals 84 to the squeeze-in system 88 to provide the driver with information concerning the velocity of other vehicles in adjacent lanes or intersecting lanes to assist the driver in determining when to safely squeeze in the lane or merge with the traffic. The CPU 18 generates control signals 86 to the intelligent cruise control system 76 to change the speed of the roadway vehicle, accelerate or brake

FIG. 1

OK

OK

the vehicle according to the speed of the obstacle. The CPU 18 generates control signals 90 to the air bag inflation system 91 to actuate the inflation device 16 for internal air bags 44 and to the air bag inflation system 92 to actuate the inflation device 16 for external air bags 14. The air bag inflation system 91 also serves to control the air bag 44 to be inflated or not, in response to the rotation of the retraction roller of the seat belt, and for the work of the air bag 14 the system 92 actuates in the minimum allowable time window at the speed more than the predetermined minimal speed settled by a vehicle experiment (e.g. 5 mph).

FIG. 32 has two different views. View 32-1 illustrates that radar 12 of conventional device mounted on the roadway vehicle 10 anticipates an imminent situation but as the radar 12 is capable of detecting only speed and distance and unable to detect the moving direction of other vehicle 20, there is no way for the radar 12 to distinguish between an actual collision situation and one in which a collision may be avoided by evasive action. View 32-2 shows that the vehicle 10 equipped with radar 12 of the present invention, based on the information of speed, distance and direction of the other vehicle 20 and speed, direction of the vehicle 10, brings forth an accurate result in determination for imminent situation, wherein 10 is roadway vehicle, 12 represents radar of the present invention and 20 is other vehicle. The radar 12 on the roadway vehicle 10 in View 32-2 detects speed, distance of 120 cm (from roadway vehicle 10 to point 24 of other vehicle 20) and direction of other vehicle 20 by extending the past track by connecting points like 23 (145 cm×4 degree on right) and 24(20 cm×10 degree on right) to predetermine a parabola to be developed (direction can be made by using L1 and L2), and such information is given to the CPU which already has information regarding speed and direction of the roadway vehicle 10 and the CPU calculates out whether collision arises or not by establishing a collision unavoidable distance according to the predetermined minimum allowable time window (e.g. 0.2 second) on the line of the parabola. If the parabola reaches the radar 12, a collision definitely arises and so the CPU orders the external air bag to inflate, but the inflation of the internal air bag requires such conditions as (1) relative speed to be more than the predetermined minimal speed prestored in the CPU, (2) safety belt to be fastened but length of the belt to be within the predetermined limit. The minimum allowable time window (M) of the present invention as seen in FIG. 32A covers time period during which a driver is unable to take action of turning steering wheel or braking to evade a collision. The minimum allowable time window (M) includes (1) time period covering from the time of returning point of the signal of said detection sensor unit on an obstacle which is the beginning time of the minimum allowable time window, up to the time when the air bag receives inflation order from said CPU, (2) time period covering from the time of said CPU orders inflation of to the air bag up to the time of the air bag is completely inflated, (3) time period covering from the time the air bag is completely inflated up to the time of a collision. No matter what type of sensor and method are used, the minimum allowable time window of the present invention is the most important one for having the air bag to inflate prior to a collision.

FIG. 33 illustrates two vehicles' movement in an imminent situation. Vehicles 10-1 and 20-1 show that both vehicles are approaching each other on a collision course. In such situation, prior to collision, drivers generally turn the steering wheel to a side to evade a collision as seen in the views 10-3, 10-4 and 20-3, 20-4 of FIG. 33. Because of the possibility of unconsciously turning the steering wheel, no one is able to accurately determine whether a collision will actually occur or not. But within the minimum allowable time window prior to collision, it is impossible for a driver to move his foot from the accelerating pedal to the brake pedal or to make a sudden turning of the steering wheel because of the extremely short period of time during which drivers are apt to lose control themselves. Therefore the distance taking the predetermined minimum allowable time (e.g. 0.2 second) to an anticipated collision point is presumed as a collision unavoidable distance. In order for the CPU to make an accurate determination for the situation whether a collision will take place or not, the following information are to be provided.

1) The information regarding the roadway vehicle 10's speed given by the speed detector and direction obtained by the direction detector of the roadway vehicle 10,

2) The information regarding other vehicle's speed, moving direction and distance from the roadway vehicle obtained through radar 12 as in 32-2 of FIG. 32.

3) With the information of 1) and 2) above, the CPU determines the collision point by calculating out a collision unavoidable distance on the basis of the predetermined minimum allowable time window with information of moving direction (parabola) of the other vehicle 20 made in the past time up to the starting point of the minimum allowable time window, as seen in View 32-2 of FIG. 32. By extending the parabola of the other vehicle 20, if the parabola reaches the roadway vehicle 10, collision will be definitely made but if the parabola doesn't reach the roadway vehicle 10 collision will not occur. As another aspect of the present invention, the CPU 18 calculates a collision point by extending the two parabolas of the roadway vehicle and the other vehicle. If the extended parabolas meet at a point, that point is a predicted collision point and a collision definitely arises when the point stays within the range of minimum allowable time window.

It is to be understood that the present invention is not limited to the embodiments described above, but encompasses any and all embodiments within the scope of the following claims.

I claim:

1. A collision damage minimizing system for a roadway vehicle comprising:

at least one detection sensor unit mounted on the roadway vehicle for detecting speed, distance and direction of a potential obstacle, said at least one detection sensor unit including transmitter means for transmitting signals and highly directional receiver means for receiving signals reflected by a potential obstacle and generating an electronic signal in response thereto;

means for detecting speed of roadway vehicle;

means for detecting direction of roadway vehicle;

a computer processing unit (CPU) for receiving information on the speed and direction of the roadway vehicle and for receiving signals from said detection sensor unit, said CPU continuously processing the information and signals and calculating changes in the speed, distance and direction of the potential obstacle with respect to the roadway vehicle, said CPU generating a control signal upon calculation of an imminent collision situation based on a predetermined minimum allowable time window, said minimum allowable time window defining a time period during which a driver of the roadway vehicle is unable to take evasive action to avoid the calculated imminent collision situation; and

at least two energy absorbing inflation devices, at least one of said energy absorbing inflation devices being

responsive to said control signal, each of said energy absorbing inflation devices including means for producing inflation gas and an electronically controlled valve for releasing said inflation gas;

at least one external air bag coupled to said valve of one of said energy absorbing inflation devices and at least one internal air bag coupled to said valve of the another of said energy absorbing inflation devices for inflation upon receiving said inflation gas, said external air bag being deflated, folded and positioned internally of the roadway vehicle upon inflation; whereby

upon calculation by the CPU of the imminent collision situation based on the predetermined minimum allowable time window, the CPU transmits the control signal to at least one of the energy absorbing inflation devices to deploy either the external air bag or the internal air bag, or both the external and internal air bag prior to time of the calculated imminent collision situation.

2. A collision damage minimizing system according to claim 1, wherein said minimum allowable time window includes (1) period beginning with time said signals returns form the potential obstacle and prior to time detection sensor unit receives said signals reflected by the potential obstacle up to the time said control signal is received by at least one of said energy absorbing inflation devices, (2) period said control signal is received by at least one of said energy absorbing inflation devices up to time said external or internal air bag is completely inflated, and (3) period said external or internal air bag is completely inflated up to time of collision.

3. A collision damage minimizing system according to claim 1, wherein said detection sensor unit is selected from the group consisting of a radiant energy detector and a sonic detector.

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US006018308A

United States Patent [19]

Shirai

[11] **Patent Number: 6,018,308**

[45] **Date of Patent: Jan. 25, 2000**

[54] **OBSTACLE RECOGNITION SYSTEM FOR AUTOMOTIVE VEHICLE**

[75] Inventor: **Noriaki Shirai**, Kariya, Japan

[73] Assignee: **Denso Corporation**, Kariya, Japan

[21] Appl. No.: **09/121,050**

[22] Filed: **Jul. 23, 1998**

[30] **Foreign Application Priority Data**

Jul. 23, 1997 [JP] Japan 9-197364

[51] **Int. Cl.**[7] **G01S 13/93**

[52] **U.S. Cl.** **342/70**; 342/61; 342/71; 342/72; 342/118; 342/175; 342/195; 701/1; 701/36; 701/301

[58] **Field of Search** 342/23, 24, 27, 342/28–32, 41, 61, 70, 71, 72, 118, 119, 146, 147, 175, 195; 701/301, 1, 36, 45, 300; 340/435

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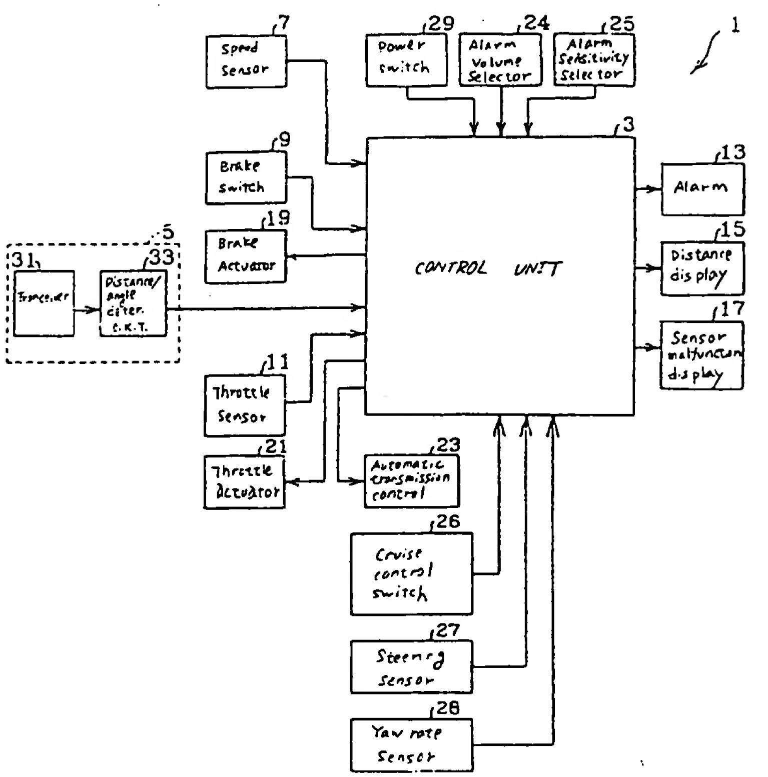
Primary Examiner—Bernarr E. Gregory
Attorney, Agent, or Firm—Pillsbury Madison & Sutro LLP

[57] **ABSTRACT**

An obstacle recognition system for automotive vehicles is provided which is designed to distinguish preceding vehicles from other objects and uses data thereof in intervehicle distance control, for example. The system includes a radar unit and a preceding vehicle determining circuit. The radar unit receives a signal produced by reflection of at least one of transmitted radar signals from an obstacle present in a given obstacle detectable zone to determine a distance to the obstacle and a horizontal and a vertical angle of the obstacle from a preselected reference direction. The preceding vehicle determining circuit includes a two-dimensional shape data producing circuit that produces two-dimensional shape data of the obstacle on a two-dimensional plane in a width-wise and a vertical direction of the system vehicle based on the distance and the horizontal and vertical angles determined by the radar unit and a non-vehicle determining circuit that determines the obstacle as an object other than the vehicle when the two-dimensional shape data of the obstacle lies out of an ordinary vehicle shape range.

9 Claims, 9 Drawing Sheets



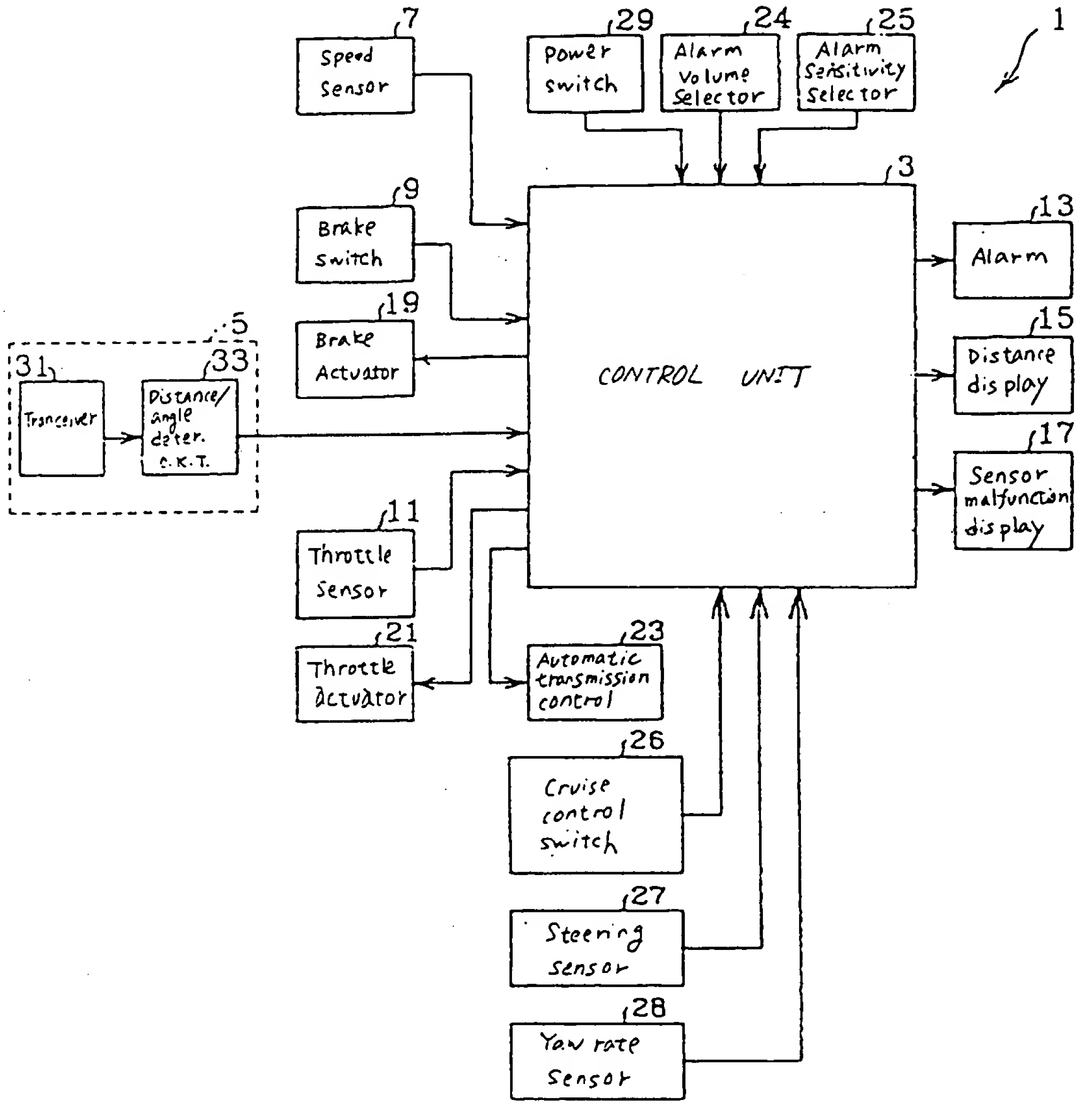

1
7
Speed Sensor
29
Power switch
24
Alarm Volume Selector
25
Alarm Sensitivity Selector
3
9
Brake switch
13
Alarm
19
Brake Actuator
5
31
Transceiver
33
Distance/angle deter. C.K.T.
CONTROL UNIT
15
Distance display
17
Sensor malfunction display
11
Throttle Sensor
21
Throttle Actuator
23
Automatic transmission control
26
Cruise control switch
27
Steering sensor
28
Yaw rate Sensor

FIG. 1

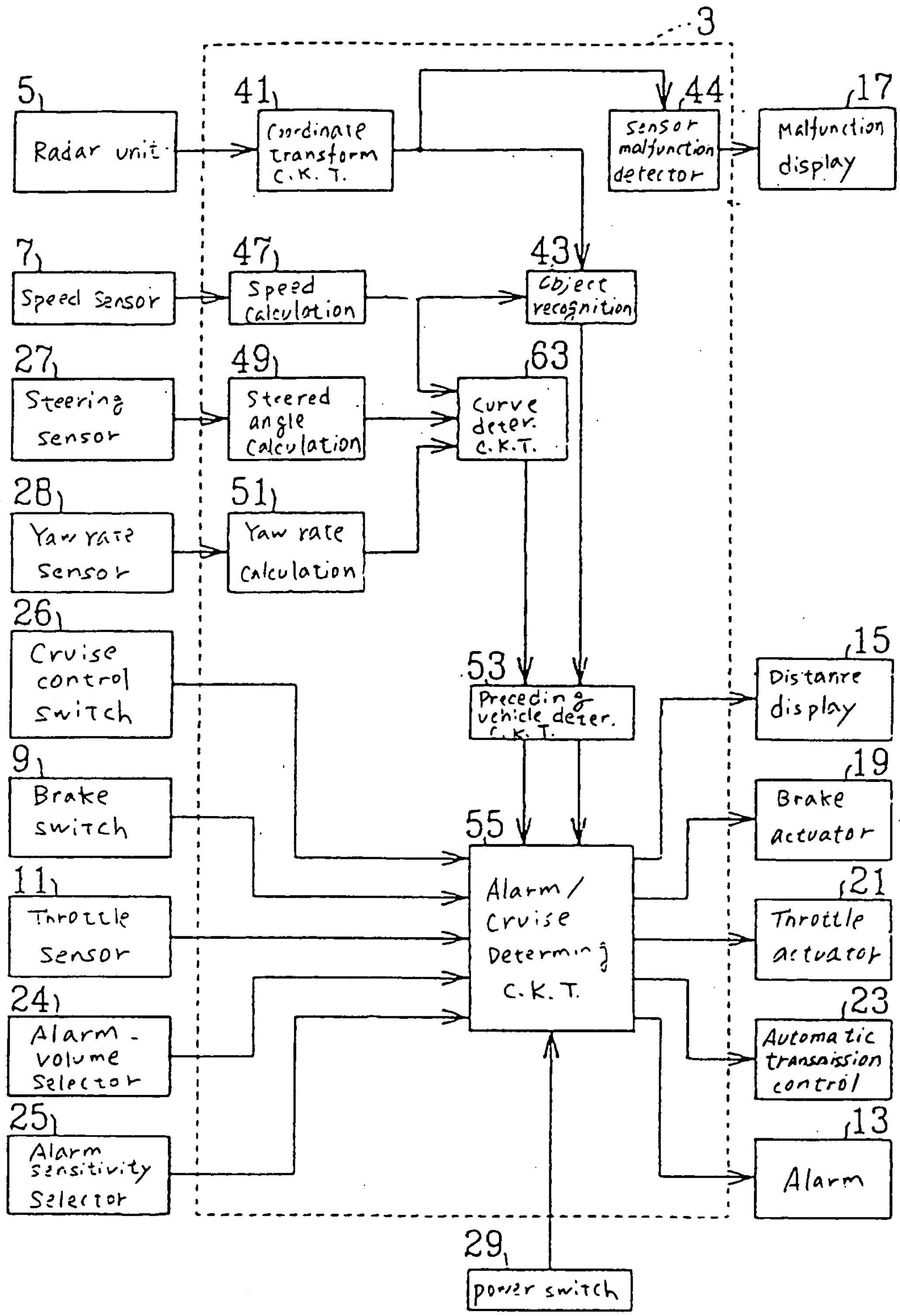

3
5
Radar unit
41
Coordinate transform C.K.T.
44
Sensor malfunction detector
17
Malfunction display
7
Speed Sensor
47
Speed Calculation
43
Object recognition
27
Steering sensor
49
Steered angle Calculation
63
Curve deter. C.K.T.
28
Yaw rate sensor
51
Yaw rate Calculation
26
Cruise control switch
53
Preceding vehicle deter. C.K.T.
15
Distance display
9
Brake switch
19
Brake actuator
55
Alarm / Cruise Determing C.K.T.
11
Throttle sensor
21
Throttle actuator
24
Alarm - volume Selector
23
Automatic transmission control
25
Alarm sensitivity Selector
13
Alarm
29
power switch

FIG. 2

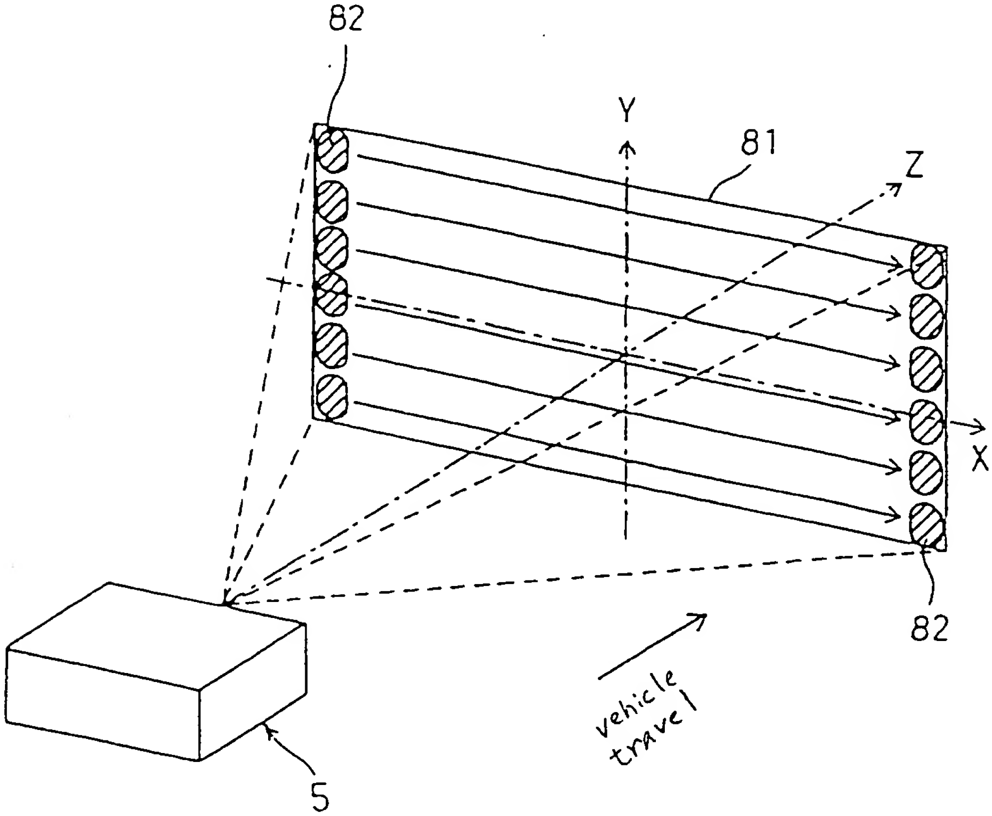

82
Y
81
Z
X
82
vehicle travel
5

FIG. 3

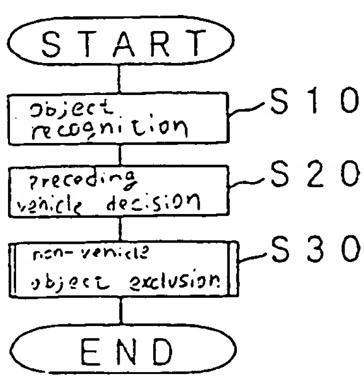

START
object recognition
S10
preceding vehicle decision
S20
non-vehicle object exclusion
S30
END

FIG. 4

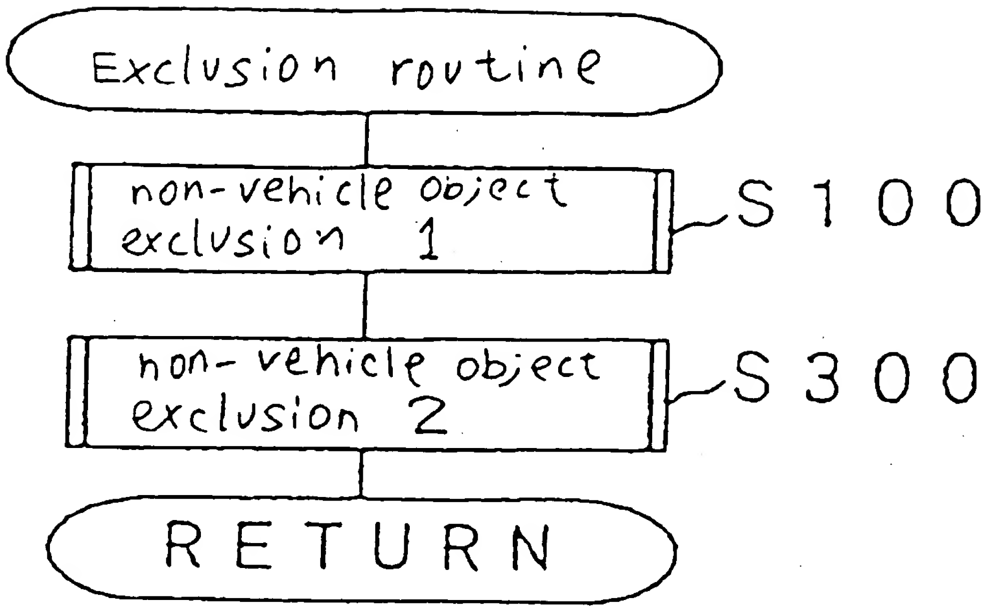
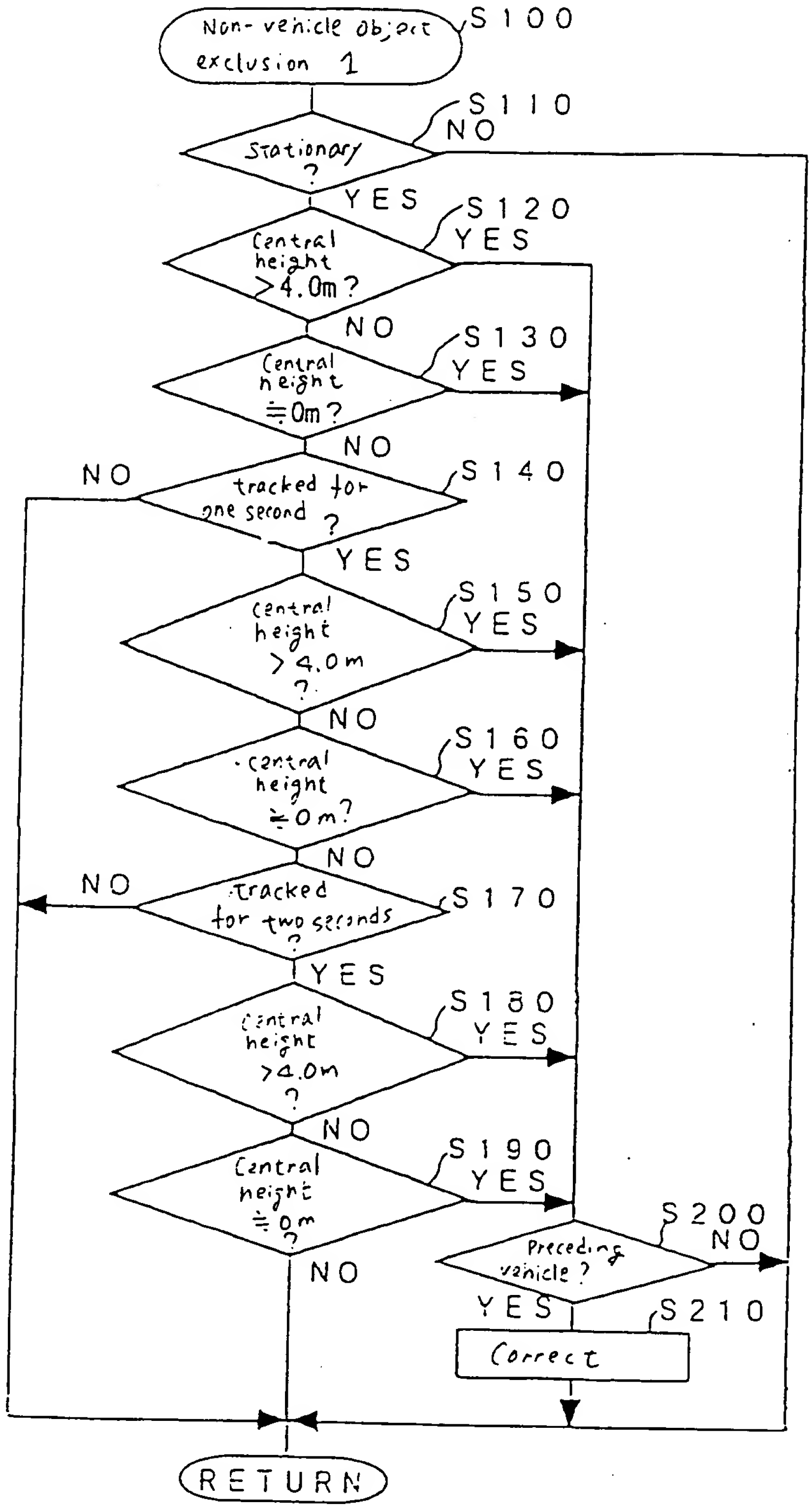

Exclusion routine
non-vehicle object exclusion 1
S100
non-vehicle object exclusion 2
S300
RETURN

FIG. 5



S100
Non-vehicle object exclusion 1
S110
Stationary ?
NO
YES
S120
Central height >4.0m ?
YES
NO
S130
Central height ≒0m ?
YES
NO
S140
tracked for one second ?
NO
YES
S150
Central height >4.0m ?
YES
NO
S160
central height ≒0m ?
YES
NO
S170
Tracked for two seconds ?
NO
YES
S180
Central height >4.0m ?
YES
NO
S190
Central height ≒0m ?
YES
NO
S200
Preceding vehicle ?
NO
YES
S210
Correct
RETURN

FIG. 6

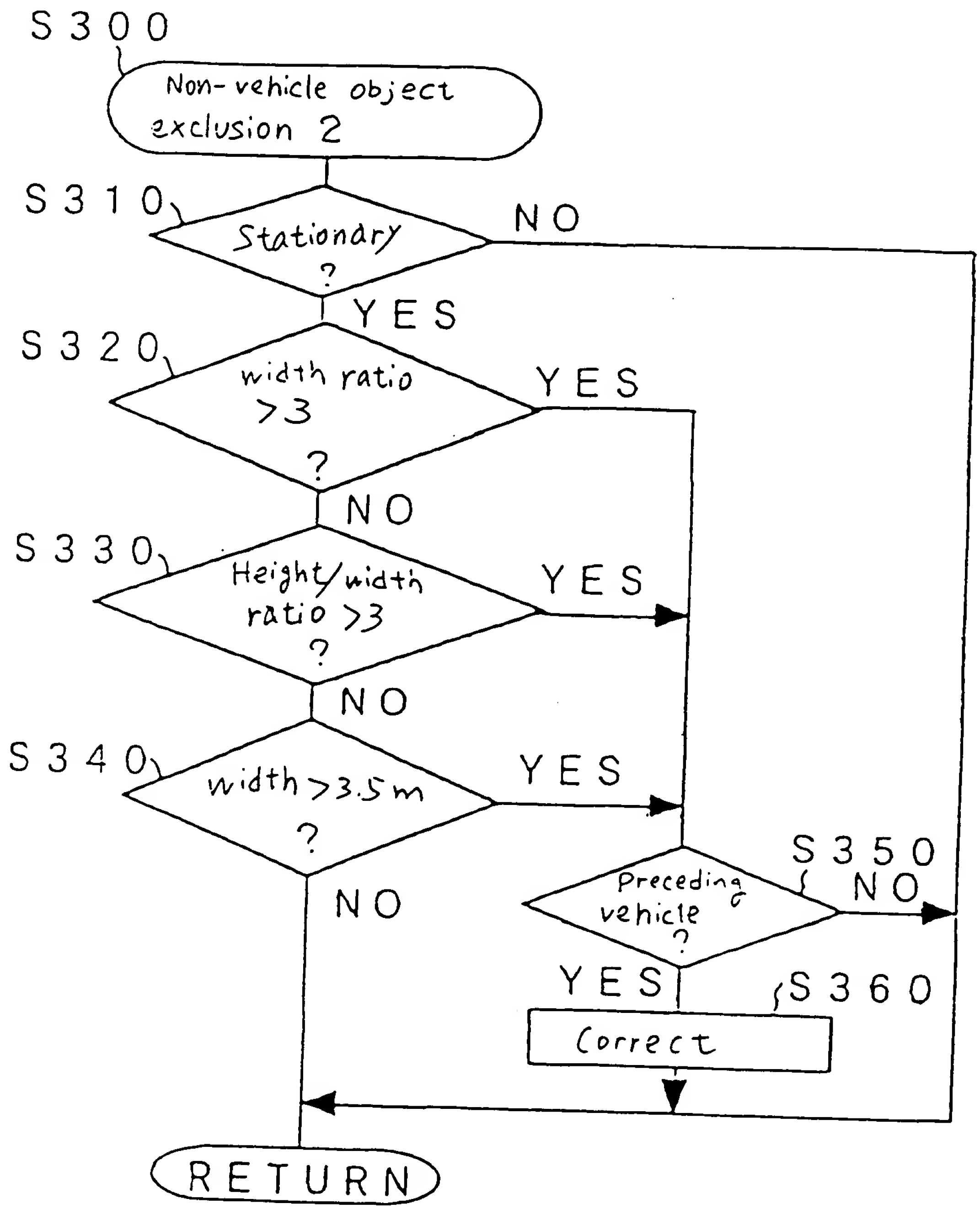

S300
Non-vehicle object exclusion 2
S310
Stationary ?
NO
YES
S320
width ratio >3 ?
YES
NO
S330
Height/width ratio >3 ?
YES
NO
S340
width >3.5m ?
YES
NO
S350
Preceding vehicle ?
NO
YES
S360
Correct
RETURN

FIG. 7

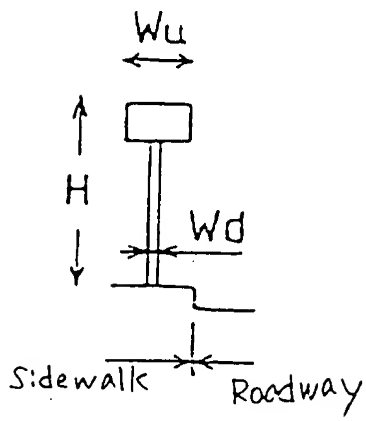


FIG. 8(a)

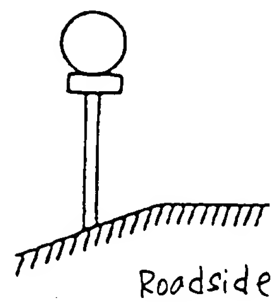


FIG. 8(b)

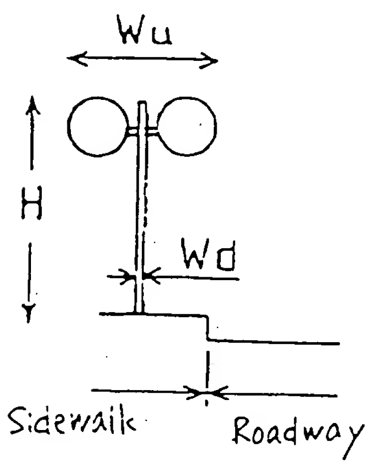


FIG. 8(c)

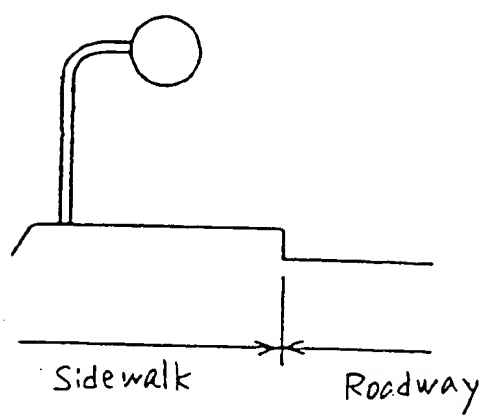


FIG. 8(d)

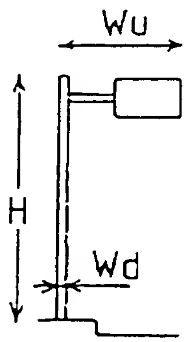


FIG. 9(a)

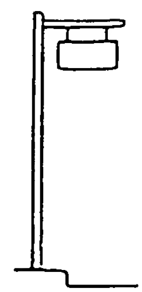


FIG. 9(b)

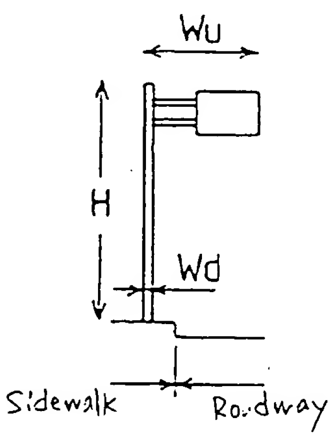


FIG. 9(c)

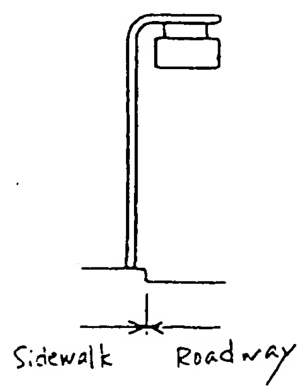


FIG. 9(d)

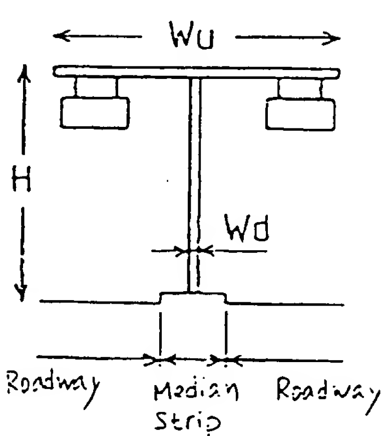


FIG. 9(e)

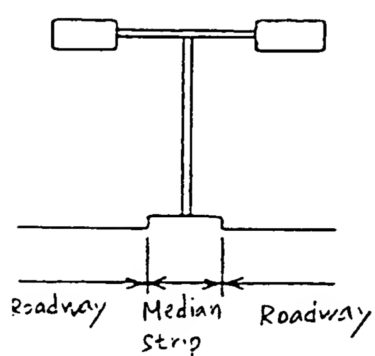


FIG. 9(f)

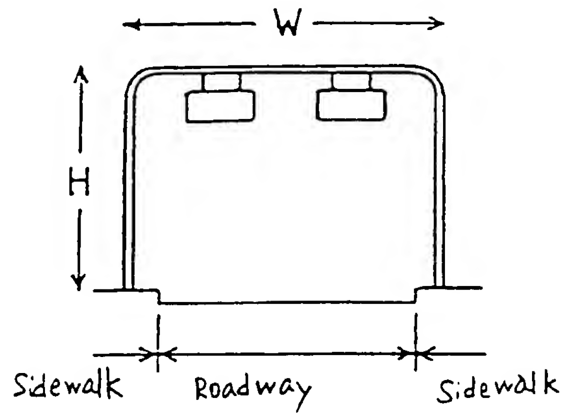


FIG. 10(a)

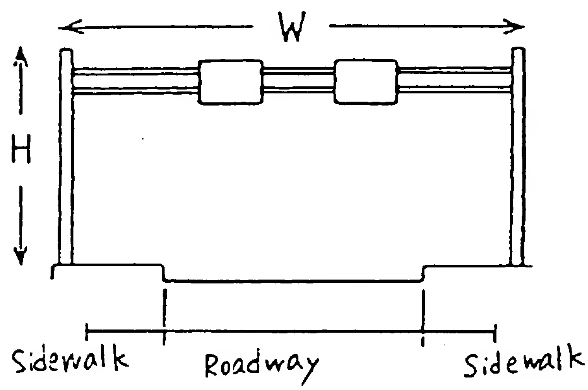


FIG. 10(b)

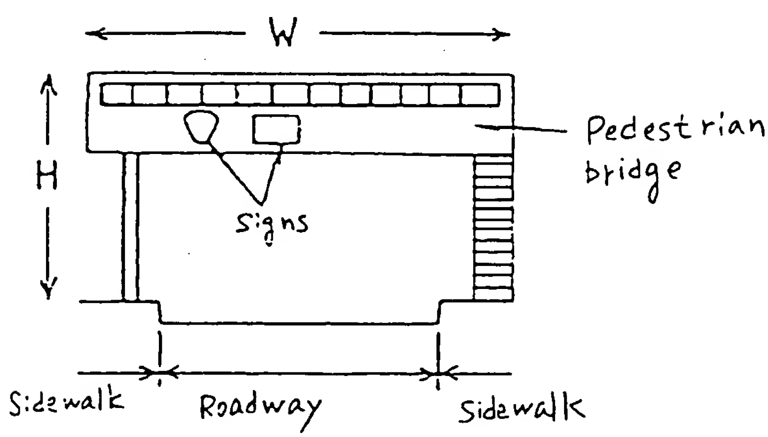


FIG. 10(c)

OBSTACLE RECOGNITION SYSTEM FOR AUTOMOTIVE VEHICLE

BACKGROUND OF THE INVENTION

1. Technical Field of the Invention

The present invention relates generally to an obstacle recognition system for use in traveling control of automotive vehicles, and more particularly, to an obstacle recognition-system capable of distinguishing vehicles present ahead of a system equipped vehicle from other objects at improved reliability and confidence levels.

2. Background of Related Art

Automotive obstacle recognition systems are known in the art which are designed to emit radar waves such as light waves and milimetric waves and receive a signal reflected from a detectable zone to recognize an object present ahead of the vehicle. As such systems, there have been proposed a collision alarm apparatus which measures the distance to an obstacle such as a preceding vehicle and issues an alarm and a cruise control apparatus which controls the speed of the vehicle to keep the distance to a preceding vehicle. These apparatuses are required to identify desired preceding vehicles as objects for the issuance of alarm and the cruise control with high accuracy. In other words, it is important to eliminate errors that obstacles on the side of a road are recognized as preceding vehicles. To this end, the prior art system distinguishes obstacles on the side of a road from preceding vehicles based on the fact that the obstacles are usually stationary and do not exist on the same lane as a controlled vehicle. Specifically, if a detected object is determined as a stationary object based on a change in position of the obstacle in a width-wise direction of the controlled vehicle and also determined as existing out of the same lane as the controlled vehicle based on the position in the width-wise direction of the controlled vehicle, the possibility that the detected object is an obstacle on either of the sides of a road is determined to be high.

It is, however, difficult to distinguish obstacles on the side of a road from preceding vehicles accurately under a variety of circumstances. For example, when a vehicle enters a curve, it is possible that a road sign provided on the side of a road will be recognized as a stationary vehicle present ahead in error. Further, when a vehicle is traveling before a downhill road or near the end of an uphill road, billboards or road signs located above a road surface which will not be detected when the vehicle is traveling on a level road may be detected as obstacles present ahead of the vehicle. Conversely, when the vehicle is traveling before an uphill road or near the end of a downhill road, the road itself or white lines and cat's-eyes on the road surface may be viewed forward of the vehicle. Therefore, the road itself and the while lines may be recognized as preceding vehicles traveling at a constant interval away from the vehicle, while the cat's-eyes may be recognized as stationary vehicles, which is an inherent performance limitation of the prior art systems designed to detect obstacles in two-dimensional direction: width-wise direction and longitudinal direction of the vehicle using a one-dimensional scan over a given angle in the width-wise direction of the vehicle.

SUMMARY OF THE INVENTION

It is therefore a principal object of the present invention to avoid the disadvantages of the prior art.

It is another object of the present invention to provide an obstacle recognition system for automotive vehicles capable of recognizing obstacles present in three-dimensional direction of a system-equipped vehicle with high reliability and confidence levels.

According to one aspect of the present invention, there is provided an obstacle recognition system for vehicles which comprises: (a) a radar unit that transmits radar signals over a given obstacle detectable zone ranging a preselected width-wise and a vertical angle of a system vehicle equipped with this system, the radar unit receiving a signal produced by reflection of at least one of the transmitted radar signals from an obstacle present in the given obstacle detectable zone to determine a distance to the obstacle and a horizontal and a vertical angle of the obstacle from a preselected reference direction; and (b) a vehicle determining means that determines whether the obstacle tracked by the radar unit is a vehicle or another object. The vehicle determining means includes (a) a height determining means that determines a height of a given portion of the obstacle based on the distance and the horizontal and vertical angles determined by the radar unit and (b) a non-vehicle determining means that determines the obstacle as an object other than the vehicle when the height of the given portion of the obstacle determined by the height determining means falls within a given height range at least one time within a predetermined period of time.

In the preferred mode of the invention, the vehicle determining means also includes obstacle movement determining means for monitoring movement of the tracked obstacle to determine whether the obstacle is a moving object or a stationary object. The non-vehicle determining means determines the obstacle as the object other than the vehicle when it is determined by the vehicle determining means that the obstacle is the stationary object and when the height of the given portion of the obstacle falls within the given height range at least one time within the predetermined period of time.

According to another aspect of the present invention, there is provided an obstacle recognition system for vehicles which comprises: (a) a radar unit that transmits radar signals over a given obstacle detectable zone ranging a preselected width-wise and a vertical angle of a system vehicle equipped with this system, the radar unit receiving a signal produced by reflection of at least one of the transmitted radar signals from an obstacle present in the given obstacle detectable zone to determine a distance to the obstacle and a horizontal and a vertical angle of the obstacle from a preselected reference direction; and (b) a vehicle determining means that determines whether the obstacle tracked by the radar unit is a vehicle or another object. The vehicle determining means includes (a) a two-dimensional shape data producing means that produces two-dimensional shape data of the obstacle on a two-dimensional plane in a width-wise and a vertical direction of the system vehicle based on the distance and the horizontal and vertical angles determined by the radar unit and (b) a non-vehicle determining means that determines the obstacle as an object other than the vehicle when the two-dimensional shape data of the obstacle produced by the two-dimensional shape data determining means lies out of an ordinary vehicle shape range.

In the preferred mode of the invention, the non-vehicle determining means determines the obstacle as the object other than the vehicle when a width ratio of a width of an upper portion to a width of a lower portion of the obstacle on the two-dimensional plane lies out of a given width ratio range. The non-vehicle determining means also determines the obstacle as the object other than the vehicle when a ratio of a height to a width of the obstacle on the two-dimensional plane lies out of a given height-to-width ratio range.

The non-vehicle determining means further determines the obstacle as the object other than the vehicle when a maximum width of the obstacle is lies out of a given maximum vehicle width range.

The vehicle determining means also includes an obstacle movement determining means that monitors movement of the tracked obstacle to determine whether the obstacle is a moving object or a stationary object. The non-vehicle determining means determines the obstacle as the object other than the vehicle when it is determined by the vehicle determining means that the obstacle is the stationary object and when the width ratio lies out of a given width ratio range or when the ratio of the height to the width of the obstacle on the two-dimensional plane lies out of a given height-to-width ratio range.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be understood more fully from the detailed description given hereinbelow and from the accompanying drawings of the preferred embodiment of the invention, which, however, should not be taken to limit the invention to the specific embodiment but are for explanation and understanding only.

In the drawings:

FIG. 1 is a block diagram which shows an automotive collision avoidance system in which an obstacle recognition system of the invention is installed;

FIG. 2 is a block diagram which shows a circuit arrangement of a control unit of a collision avoidance system;

FIG. 3 is a perspective view which shows an obstacle detectable zone scanned by a radar unit;

FIG. 4 is a flowchart of a program performed by an obstacle recognition system;

FIG. 5 is a flowchart of a program to exclude non-vehicle objects from obstacles tracked by a radar unit;

FIG. 6 is a flowchart of a first non-preceding vehicle excluding sub-program executed in the program of FIG. 5;

FIG. 7 is a flowchart of a second non-preceding vehicle excluding sub-program executed in the program of FIG. 5;

FIGS. 8(*a*), 8(*b*), 8(*c*), and 8(*d*) show ordinary roadside road signs;

FIGS. 9(*a*), 9(*b*), 9(*c*), 9(*d*), 9(*e*), and 9(*f*) show ordinary overhung road signs; and

FIGS. 10(*a*), 10(*b*), and 10(*c*) show road signs bridging over the roadway.

DESCRIPTION OF THE PREFERRED EMBODIMENT

An obstacle recognition system of the invention will be described below with reference to the drawings, taking an automotive collision avoidance system as an example.

FIG. 1 shows the automotive collision avoidance system 1 which is designed to track obstacles present ahead of an automotive vehicle equipped with this system (hereinafter, referred to as a system vehicle) for raising an alarm to inform a vehicle operator of the possibility of collision when a distance between the obstacle and the system vehicle reaches a warning distance and to control the speed of the system vehicle so as to follow a selected preceding vehicle at a constant intervehicle distance.

The automotive collision avoidance system 1 includes a control unit 3 provided with a microcomputer, an input/output interface circuit, driving circuits, and detection circuits which can be of any known arrangements, and explanation thereof in detail will be omitted here.

The control unit 3 receives detection signals outputted from a distance/azimuth measuring device 5, a speed sensor 7, a brake switch 9, and a throttle opening sensor 11, and provides control signals to an alarm sound generator 13, a distance display 15, a sensor malfunction display 17, a brake actuator 19, a throttle actuator 21, and an automatic transmission control unit 23.

The automotive collision avoidance system 1 further includes an alarm volume selector 24, an alarm sensitivity selector 25, a power switch 29, a cruise control switch 26, a steering sensor 27, and a yaw rate sensor 28. The alarm volume selector 24 is designed to manually adjust the volume on the alarm sound generator 13. The alarm sensitivity selector 25 is designed to manually adjust the sensitivity of an alarm decision operation. The power switch 29 is designed to be turned on manually or in response to activation of an ignition switch to supply the power to the control unit 3. The cruise control switch 26 is designed to manually turn on the cruise control. The steering sensor 27 measures a steered angle of a steering wheel of the system vehicle and provides a signal indicative thereof to the control unit 3. The yaw rate sensor 28 measures a yaw rate of the vehicle body and provides a signal indicative thereof to the control unit 3.

The distance/azimuth measuring device 5 is implemented with a radar unit which includes a transceiver 31 and a distance/angle determining circuit 33. The transceiver 31 is provided with a scanner which transmits a laser beam in cycles in horizontal and vertical directions of the system vehicle to scan a forward detectable range defined by given horizontal and vertical angles and receives a beam reflected from an object or target present ahead of the system vehicle. The distance/angle determining circuit 33 determines a relative speed between the system vehicle and the target, a distance to the target, and coordinates of the target based on the length of time between the transmission of the laser beam and reception thereof. An example of a scan pattern of the laser beam emitted by the transceiver 31 is shown in FIG. 3. Each hatched portions 82 indicates a cross section of the laser beam emitted over the detectable range 81. The laser beam may alternatively be oval or rectangular in cross section. The distance/azimuth measuring device 5 can be of any arrangement other than a scanner capable of measuring the distance to a target in two-dimensional direction and may use a microwave or a supersonic wave.

In FIG. 3, if the central optical axis of the transceiver 31 is defined as Z-axis, an X-Y area or detectable zone 81 defined perpendicular to the Z-axis is scanned. In this embodiment, X-axis indicates the direction in which scanning lines extend horizontally, while Y-axis indicates an elevation of the detectable zone 81. The X-Y area is defined by 0.15°×105 laser pulses=16° in the X-axis direction and 0.7°×6 scanning lines=4°. The scan is performed from left to right and from top to bottom of the detectable zone 81. In practice, laser pulses are first scanned along the uppermost scanning line in the X-axis direction. Upon reaching the right end of the uppermost scanning line, the laser pulses are next scanned along the second scanning line immediately below the uppermost scanning line. In this way, the scans are performed up to the sixth scanning line to derive 105 laser pulses×6 scanning lines=630 data components in the transceiver 31. In FIG. 3, the fourth scanning is located flush with the vehicle (i.e., the central optical axis of the distance/azimuth measuring device 5).

The distance/angle determining circuit 33 receives the 630 components from the transceiver 31 to provide data signals indicative of horizontal and vertical scanning angles

θx and θy and the distance r to a tracked object. The horizontal angle θx is the angle which a line of an output laser beam projected onto the X-Z plane makes with the Z-axis. The vertical scanning angle θy is the angle which the output laser beam makes with the X-Z plane.

The control unit 3 is responsive to the data signals from the distance/azimuth measuring scanner 5 to determine if a tracked obstacle such as a vehicle traveling ahead of the system vehicle, a parked vehicle, a guard rail, or a pole installed on the side of a road lies within an warning zone for a preselected period of time or not. If so, the control unit 3 concludes that there is a high possibility of collision, and raises an alarm to the vehicle operator through the alarm sound generator 13. In addition, the control unit 3 may perform cruise control that controls the brake actuator 19, the throttle actuator 21, and/or the automatic transmission control unit 23 to regulate the speed of the system vehicle according to the status of the tracked obstacle.

The control unit 3, as shown in FIG. 2, includes a spherical-to-rectangular coordinate transformation circuit 41, a sensor malfunction determining circuit 44, an object recognition circuit 43, a speed determining circuit 47, a steered angle determining circuit 49, a yaw rate determining circuit 51, a radius-of-curvature determining circuit 63, a preceding vehicle decision circuit 53, and an alarm/cruise determining circuit 55.

The spherical-to-rectangular coordinate transformation circuit 41 receives from the distance measuring scanner 5 data on the horizontal and vertical scanning angles θx and θy and the distance r to a tracked object and transfers it to a point in an X-Y-Z rectangular coordinate system whose origin (0, 0, 0) is defined on the system vehicle. The sensor malfunction determining circuit 44 determines whether values transferred in the X-Y-Z coordinate system represent normal values or not, and provides a signal indicative thereof to the sensor malfunction display 17.

The object recognition circuit 43 determines the type of a tracked obstacle, coordinates (x, y, z) of central position of the obstacle, the size data (W, D, H) on the obstacle, and the shape data on the obstacle based on the speed V of the system vehicle, the relative speed between the system vehicle and the obstacle, and the x-, y-, and z-coordinates determined by the spherical-to-rectangular coordinate transformation circuit 41. The determination of the type of the obstacle is made to determine whether the obstacle is a moving object or a stationary one based on the vehicle speed V and the relative speed. When a plurality of obstacles are detected, ones which will disturb traveling of the system vehicle are selected, and distances to the selected obstacles are indicated through the distance display 15. The size data (W, D, H) indicates the length of sides of a minimum rectangular parallelepiped containing therein the obstacle geometrically (i.e., width, depth, and height of the rectangular parallelepiped). The shape data indicates parameters other than the size data (W, D, H), for example, an upper width Wu and a lower width Wd of the obstacle on the X-Y coordinate plane.

The speed determining circuit 47 is responsive to a signal from the speed sensor 7 to determine the speed Vn of the system vehicle and provides a signal indicative thereof to the object recognition circuit 43. The object recognition circuit 43 monitors a variation in central position of the tracked obstacle per unit time to determine the relative speed between the system vehicle and the obstacle based on the vehicle speed Vn determined by the speed determining circuit 47. The relative speed is represented by the vector sum of x-, y-, and x-axis components (Vx, Vy, Vz).

The steered angle determining circuit 47 determines the steered angle of the steering wheel of the system vehicle based on an output from the steering sensor 27 and provides a signal indicative thereof to the radius-of-curvature determining circuit 63. The yaw rate determining circuit 51 determines the yaw rate of the system vehicle based on an output from the yaw rate sensor 28 and provides a signal indicative thereof to the radius-of-curvature determining circuit 63.

The radius-of-curvature determining circuit 63 uses the vehicle speed Vn determined by the vehicle speed determining circuit 47, the steered angle determined by the steered angle determining circuit 49, and the yaw rate determined by the yaw rate determining circuit 51 to calculate the radius of curvature R of a road on which the system vehicle is traveling. The preceding vehicle decision circuit 53 determines whether the tracked obstacle is a preceding vehicle traveling ahead of the system vehicle on the same traffic lane or not based on the radius of curvature R, the type of the obstacle, the coordinates (x, y, z) of the central position of the obstacle, the size data (W, D, H), the relative speed components (Vx, Vy, Vz) and determines the distance Z to and relative speed Vz of the obstacle if determined as a preceding vehicle.

The alarm/cruise determining circuit 55 determines in an alarm mode whether an alarm is to be raised or not or determines in a cruise mode the contents of speed control based on the distance Z to the preceding vehicle, the relative speed Vz, the vehicle speed Vn, the acceleration of the preceding vehicle, a brake pedal effort detected by the brake switch 9, an opening degree of the throttle sensed by the throttle opening sensor 11, a value of sensitivity set by the alarm sensitivity selector 25. When it has been concluded that an alarm needs to be raised, the alarm/cruise determining circuit 55 provides an alarm generating signal to the alarm sound generator 13. Alternatively, the alarm/cruise determining circuit 55, in the cruise mode, provides control signals to the automatic transmission control unit 23, the brake actuator 19, and the throttle actuator 21 to perform given cruise control.

FIG. 4 shows a flowchart of an object recognition program performed by the control unit 3 in the so-called intervehicle distance control for determining whether a tracked object is a preceding vehicle traveling on the same traffic lane as that of the system vehicle or not.

After entering the program, the routine proceeds to step 10 wherein using 630 data components (=105 laser pulses×6 scanning lines) derived in the receiver 31 of the distance/azimuth measuring device 5 by scanning the detectable zone 81 defined by a horizontal angle of 16° (=0.15°×105 laser pulses) and a vertical angle of 4°(=0.7°×6 scanning lines), the distance/angle determining circuit 33 provides data signals indicative of horizontal and vertical scanning angles θx and θy and the distance r to a tracked obstacle which are, in turn, transformed by the spherical-to-rectangular coordinate transformation circuit 41 into coordinates (x, y, z) in the rectangular X-Y-Z coordinate system. The object recognition circuit 43 uses the coordinate data inputted from the spherical-to-rectangular coordinate transformation circuit 41 to determine the type of the obstacle, the coordinates (x, y, z) of central position of the obstacle, the size data CV, D, H), the shape data, and the relative speed components (Vx, Vy, Vz) of the obstacle. The relative speed components (Vx, Vy, Vz) are, as described above, derived based on variations in coordinates (x, y, z) of central position of the obstacle per unit time, respectively. For the type of the obstacle, if the system vehicle is traveling, but a relative position of the

obstacle (i.e., the relative speed of the obstacle) hardly changes, then the obstacle is identified as a moving object. Additionally, if the obstacle is moving away from the system vehicle, that is, the relative speed of the obstacle is increasing, then the obstacle is also identified as a moving object. If the relative position of the obstacle is approaching the system vehicle at the speed equal in absolute value to the vehicle speed Vn of the system vehicle, then the obstacle is identified as a stationary object.

The routine proceeds to step **20** wherein it is determined whether the obstacle is a preceding vehicle or not in the following manner. First, the radius of curvature R of a road on which the system vehicle is now traveling is determined in the radius-of curvature determining circuit **63**. A same lane probability that the obstacle determined in step **10** exists in the same traffic lane as the system vehicle is determined using the radius of curvature R and the position of the obstacle on the X-Z plane in FIG. 3. When a plurality of obstacles are detected by the distance/azimuth measuring circuit **5**, the same lane probability of each obstacle is determined. Next, from among the obstacles having the same lane probabilities of more than a preselected value, a target preceding vehicle(s) is selected. The determination of the same lane probability and selection of the target preceding vehicle may be made in a manner as taught in U.S. Pat. No. 5,710,565 (corresponding to German Patent Application laid open on Oct. 10, 1996 under DE196 14 061 A1), issued on Jan. 20, 1998, assigned to the same assignee as that of this application, disclosure of which is incorporated herein by reference.

The determination in step **20** has a possibility that some non-preceding vehicle on or above the road is determined as a preceding vehicle. For example, a road itself or objects disposed on or above a lane on which the system vehicle is now traveling such as road signs, overpasses, white lines, and cat's eyes on a white line may be determined as preceding vehicles in error. Step **30**, as discussed below, excludes such objects from targets determined as preceding vehicles.

Upon entering step **30**, the routine proceeds to step **100** in FIG. **5** to execute a first non-preceding vehicle excluding sub-program to exclude non-preceding vehicles from all obstacles tracked by the distance/azimuth measuring device **5** in terms of the height of tracked obstacles. After the non-preceding vehicles are excluded from the obstacles in step **100**, the routine proceeds to step **300** to execute a second non-preceding vehicle excluding sub-program to exclude non-preceding vehicles from all obstacles tracked by the distance/azimuth measuring device **5** in terms of the shape of the tracked obstacle.

FIG. 6 shows the first non-preceding vehicle excluding program.

First, in step **110**, it is determined whether each tracked obstacle is at rest or not based on the decision in step **10** in FIG. 4. This determination is based on the fact that most of obstacles determined as preceding vehicles in error are usually stationary objects located on or above the road. If a NO answer is obtained meaning that the obstacle is moving, that is, that the preceding vehicle is traveling, then the routine terminates without executing step **120** and later steps. This prevents a traveling preceding vehicle from being determined as a non-preceding vehicle in error at the beginning and end of a slope, for example. Alternatively, if a YES answer is obtained in step **110**, then the routine proceeds to step **120** wherein it is determined whether the height of the center of the obstacle from a road surface is greater than 4.0 m or not. If a NO answer is obtained, then the routine proceeds to step **130** wherein it is determined whether the central height of the obstacle is nearly 0 m or not. If a YES answer is obtained in either of steps **120** and **130**, then the routine proceeds to step **200** wherein it is determined whether the obstacle has already been determined as a preceding vehicle in step **20** in FIG. **4** or not. If a YES answer is obtained, then the routine proceeds to step **210** wherein the determination in step **20** is corrected, and the obstacle is recognized as a non-preceding vehicle. The routine then terminates.

The central height of the obstacle to be used in determinations in steps **120** and **130** is calculated based on the coordinates (x, y, z) of the central position of the obstacle derived in the object recognition circuit **43**. The reason that the obstacle is determined as a non-preceding vehicle when the central height of the obstacle is greater than 4.0 m or nearly equal to 0 m is because the central heights of typical vehicles are hardly equal to 0 m or greater than 4.0 m. Specifically, in Japan, typical trucks or trailers have a maximum height of 3.8 m, and the bottom of vehicles is spaced apart from a road surface by several centimeters. It is, thus, possible to determine the obstacle as a non-preceding vehicle when the central height thereof is greater than 4.0 m or nearly equal to 0 m.

If a NO answer is obtained in step **130** meaning that the central height of the obstacle lies within a range from 0 to 4.0 m, then the routine proceeds to step **140** to refer to height data on the same obstacle derived in previous program execution cycles. This is because when the system vehicle is traveling before a downhill road or near the end of an uphill road, overhead billboards or road signs located 4 m above a road surface, which should not be tracked by the distance/azimuth measuring circuit **5** when the system vehicle is traveling on a level road, will be viewed in front of the system vehicle and recognized as preceding vehicles in error. Further, when the system vehicle is traveling before an uphill road or near the end of a downhill road, the road itself, white lines on the road, or cat's eyes mounted on the white line will appear in front of the system vehicle and recognized as preceding vehicles in error. Therefore, such erroneous recognition is corrected using the previous height data as discussed below.

In step **140**, it is determined whether the obstacle continues to be tracked for one second or not. If a NO answer is obtained, then the routine terminates. Alternatively, if a YES answer is obtained, then the routine proceeds to step **150** wherein it is determined whether the central height of the obstacle when tracked one second before is greater than 4.0 m or not. If a NO answer is obtained, then the routine proceeds to step **160** wherein it is determined whether the central height of the obstacle when tracked one second before is nearly equal to 0 m or not. If a YES answer is obtained in either of steps **150** and **160**, then the routine proceeds to step **200**.

If a NO answer is obtained in step **160**, then the routine proceeds to step **170** wherein it is determined whether the obstacle continues to be tracked for two seconds or not. If a YES answer is obtained, then the routine proceeds to step **180** wherein it is determined whether the central height of the obstacle when tracked two seconds before is greater than 4.0 m or not. If a NO answer is obtained, then the routine proceeds to step **190** wherein it is determined whether the central height of the obstacle when tracked two seconds before is nearly equal to 0 m or not. If a NO answer is obtained, then the routine terminates. Alternatively, if a YES answer is obtained in either of steps **180** and **190**, then the routine proceeds to step **200**.

After termination of the sub-program in FIG. 4, the routine proceeds to step **300** in FIG. 5. The sub-program in step **300** is performed for all the tracked obstacles.

First, in step **310**, it is determined whether the tracked obstacle is at rest or not based on the decision in step **10** in FIG. 4. If a NO answer is obtained, then the routine terminates. Alternatively, if a YES answer is obtained, then the routine proceeds to step **320** wherein it is determined whether a ratio (Wu/Wd) of the upper width Wu of an upper end of the obstacle on the X-Y plane in FIG. **3** to the lower width Wd of a lower end thereof is greater than three (3) or not. If a NO answer is obtained, then the routine proceeds to step **330** wherein it is determined whether a ratio (H/W) of the height H to the width W of the obstacle is greater than three (3) or not. If a NO answer is obtained, then the routine proceeds to step **340** wherein it is determined whether a maximum width W of the obstacle is greater than 3.5 m or not. If a NO answer is obtained, then the routine terminates. Alternatively, if a YES answer is obtained in any of steps **320**, **330**, and **340**, then the routine proceeds to step **350** wherein it is determined whether the obstacle has already been determined as a preceding vehicle in step **20** in FIG. 4 or not. If a YES answer is obtained, then the routine proceeds to step **360** wherein the determination in step **20** is corrected, and the obstacle is recognized as a non-preceding vehicle. The routine then terminates.

The determinations in steps **320**, **330**, and **340** are, as can be seen from the above, made for determining whether the shape of the obstacle falls within a range of shapes of ordinary vehicles or not. The reason that when it is determined in step **320** that the width ratio (Wu/Wd) is greater than 3, the obstacle is recognized as a preceding vehicle is as follows. Usually, road signs are, as shown in FIGS. **8**(*a*) to **8**(*d*) and FIGS. **9**(*a*) to **9**(*f*), installed on upper ends of support poles and have, in most cases, the width ratio (Wu/Wd) of 3 or more which ordinary automotive vehicles never have. The use of the width ratio (Wu/Wd) in determination in step **320**, thus, allows ordinary automotive vehicles to be distinguished from non-vehicle objects such as road signs.

The reason that when it is determined in step **330** that the height-to-width ratio (H/W) is greater than 3, the obstacle is recognized as a preceding vehicle is as follows. Most of the road signs, as shown in FIGS. **8**(*a*) to **8**(*d*) and FIGS. **9**(*a*) to **9**(*f*), have a height of 2 to 3 m or more, but the width thereof is usually small, so that the height-to-width ratio (H/W) will be greater than 3. For example, the inverse L-shaped overhung road signs, as shown in FIGS. **9**(*a*) and **9**(*b*), and the L-shaped overhung road sign, as shown in FIG. **9**(*c*), are usually located 5 m above a road surface for avoiding interference with vehicles traveling on the roadway. Thus, even when the width of the road signs is, for example, 1 m, the height-to-width ratio (H/W) will be 5 which is greater than 3 and which ordinary automotive vehicles never have. The use of the height-to-width ratio (H/W) in determination in step **330**, thus, allows ordinary automotive vehicles to be distinguished from non-vehicle objects such as road signs.

Most of ordinary road signs can be distinguished from the automotive vehicles by either of the determinations in steps **320** and **330**, but this embodiment uses the two determinations in steps **320** and **330** to improve the accuracy of discrimination between the automotive vehicles and non-vehicle objects. For example, the T-shaped road signs, as shown in FIGS. **9**(*e*) and **9**(*f*), have a height-to-width of close to one (1) and difficult to distinguish from the automotive vehicle only in the determination in step **330**, but it have an upper-to-lower width ratio (Wu/Wd) of 3 or more and can be distinguished from the automotive vehicle by use of the determination in step **320**.

The reason that when it is determined in step **340** that the width W is greater than 5 m, the obstacle is recognized as a preceding vehicle is as follows. Special road signs such as ones, as shown in FIGS. **10**(*a*) and **10**(*b*), mounted on support poles bridging over the roadway and, as shown in FIG. **10**(*c*), attached to a side wall of a pedestrian bridge have a height-to-width ratio (H/W) of less than one (**1**). For the upper-to-lower width ratio (Wu/Wd), it is difficult to determine which part of the road sign is a lower width, thus resulting in a negative answer in either of steps **320** and **330**. Further, for the T-shaped road signs shown in FIGS. **9**(*e*) and **9**(*f*), only upper portions hanging over the roadway may be recognized as obstacles. In this case, they are difficult to exclude from the targets as determined as preceding vehicles in the determinations in steps **320** and **330**. For these reasons, step **340** is executed to compare the width of the obstacle with a reference value (3.5 m) which ordinary automotive vehicles never have to recognize the obstacle as a non-preceding vehicle if a maximum width thereof is greater than the reference value. For example, the road signs, as shown in FIGS. **10**(*a*), **10**(*b*), and **10**(*c*), have maximum widths which exceed the width of one traffic lane and which is greater than 3.5 m.

While the present invention has been disclosed in terms of the preferred embodiment in order to facilitate a better understanding thereof, it should be appreciated that the invention can be embodied in various ways without departing from the principle of the invention. Therefore, the invention should be understood to include all possible embodiments and modification to the shown embodiments which can be embodied without departing from the principle of the invention as set forth in the appended claims. For example, criteria of the width ratio (Wu/Wd) and the height-to width ratio (H/W) used in determinations in steps **320** and **330** are not always limited to three (3) and may alternatively be 2.5. Specifically, the criteria of the width ratio (Wu/Wd) and the height-to width ratio (H/W) may be any values which ordinary automotive vehicles never have. Further, after step **190** in FIG. 6, a step which uses height data derived three or four seconds earlier may also be provided to improve the accuracy of non-vehicle determination in steps **200** and **210**. The use of old height data, however, makes it difficult to identify targets. The use of height data derived up to two seconds earlier is found experimentally to be preferable.

What is claimed is:

1. An obstacle recognition system for vehicles comprising:

a radar unit that transmits radar signals over a given obstacle detectable zone ranging a preselected widthwise and a vertical angle of a system vehicle equipped with this system, said radar unit receiving a signal produced by reflection of at least one of the transmitted radar signals from an obstacle present in the given obstacle detectable zone to determine a distance to the obstacle and a horizontal and a vertical angle of the obstacle from a preselected reference direction; and

vehicle determining means for determining whether the obstacle tracked by said radar unit is a vehicle or another object, said vehicle determining means including

height determining means for determining a height of a given portion of the obstacle based on the distance and the horizontal and vertical angles determined by said radar unit, and

non-vehicle determining means for determining the obstacle as an object other than the vehicle when the height of the given portion of the obstacle determined by said height determining means falls within a given height range at least one time within a predetermined period of time.

2. An obstacle recognition system as set forth in claim 1, wherein said vehicle determining means also includes obstacle movement determining means for monitoring movement of the tracked obstacle to determine whether the obstacle is a moving object or a stationary object, and wherein said non-vehicle determining means determines the obstacle as the object other than the vehicle when it is determined by said vehicle determining means that the obstacle is the stationary object and when the height of the given portion of the obstacle falls within the given height range at least one time within the predetermined period of time.

3. An obstacle recognition system for vehicles comprising:

a radar unit that transmits radar signals over a given obstacle detectable zone ranging a preselected width-wise and a vertical angle of a system vehicle equipped with this system, said radar unit receiving a signal produced by reflection of at least one of the transmitted radar signals from an obstacle present in the given obstacle detectable zone to determine a distance to the obstacle and a horizontal and a vertical angle of the obstacle from a preselected reference direction; and

vehicle determining means for determining whether the obstacle tracked by said radar unit is a vehicle or another object, said vehicle determining means including

two-dimensional shape data producing means for producing two-dimensional shape data of the obstacle on a two-dimensional plane in a width-wise and a vertical direction of the system vehicle based on the distance and the horizontal and vertical angles determined by said radar unit, and

non-vehicle determining means for determining the obstacle as an object other than the vehicle when the two-dimensional shape data of the obstacle produced by said two-dimensional shape data determining means lies out of an ordinary vehicle shape range.

4. An obstacle recognition system as set forth in claim 3, wherein the two-dimensional shape data is a width ratio of a width of an upper portion to a width of a lower portion of the obstacle on the two-dimensional plane.

5. An obstacle recognition system as set forth in claim 4, wherein said vehicle determining means also includes obstacle movement determining means for monitoring movement of the tracked obstacle to determine whether the obstacle is a moving object or a stationary object, and wherein said non-vehicle determining means determines the obstacle as the object other than the vehicle when it is determined by said vehicle determining means that the obstacle is the stationary object and when the width ratio lies out of a given width ratio range.

6. An obstacle recognition system as set forth in claim 3, wherein the two-dimensional shape data is a ratio of a height to a width of the obstacle on the two-dimensional plane.

7. An obstacle recognition system as set forth in claim 6, wherein said vehicle determining means also includes obstacle movement determining means for monitoring movement of the tracked obstacle to determine whether the obstacle is a moving object or a stationary object, and wherein said non-vehicle determining means also determines the obstacle as the object other than the vehicle when it is determined by said vehicle determining means that the obstacle is the stationary object and when the ratio of the height to the width of the obstacle on the two-dimensional plane lies out of a given height-to-width ratio range.

8. An obstacle recognition system as set forth in claim 3, wherein said non-vehicle determining means determines the obstacle as the object other than the vehicle when a width ratio of a width of an upper portion to a width of a lower portion of the obstacle on the two-dimensional plane lies out of a given width ratio range, and wherein said non-vehicle determining means also determines the obstacle as the object other than the vehicle when a ratio of a height to a width of the obstacle on the two-dimensional plane lies out of a given height-to-width ratio range.

9. An obstacle recognition system as set forth in claim 3, wherein said non-vehicle determining means further determines the obstacle as the object other than the vehicle when a maximum width of the obstacle is lies out of a given maximum vehicle width range.

* * * * *

US006114951A

United States Patent [19]

Kinoshita et al.

[11] Patent Number: 6,114,951

[45] Date of Patent: Sep. 5, 2000

[54] VEHICLE COLLISION PREVENTING APPARATUS

[75] Inventors: Masahiro Kinoshita, Ota; Atsushi Ikeda, Ashikaga, both of Japan

[73] Assignee: Fuji Jukogyo Kabushiki Kaisha, Tokyo, Japan

[21] Appl. No.: 08/992,605

[22] Filed: Dec. 17, 1997

[30] Foreign Application Priority Data

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[51] Int. Cl.[7] B60Q 1/00

[52] U.S. Cl. 340/436; 340/901; 340/903; 340/904; 340/435

[58] Field of Search 340/901, 903, 340/904, 935, 436, 437; 348/149; 701/301, 70, 77, 78, 79, 80, 93, 96

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Primary Examiner—Daryl Pope
Attorney, Agent, or Firm—Martin A. Farber

[57] ABSTRACT

A collision preventing apparatus of a vehicle for preventing a collision with a preceding vehicle running ahead of the vehicle has an image processor and a computer for calculating inter-vehicle distance, an inter-vehicle distance between the vehicle and the preceding vehicle, and a safe-inter vehicle distance between the vehicle and the preceding vehicle while observing a third vehicle running ahead of the preceding vehicle, judging a hazard of collision with the preceding vehicle based on the inter-vehicle distance and the safe inter-vehicle distance, and warning a driver of the hazard. Since the vehicle having the collision preventing apparatus runs calculating the inter-vehicle distance in conjunction with the third vehicle, a collision with the preceding vehicle can be prevented, even when a driver of the preceding vehicle applies an emergency brake to avoid a collision with the third vehicle running ahead of the preceding vehicle.

3 Claims, 6 Drawing Sheets

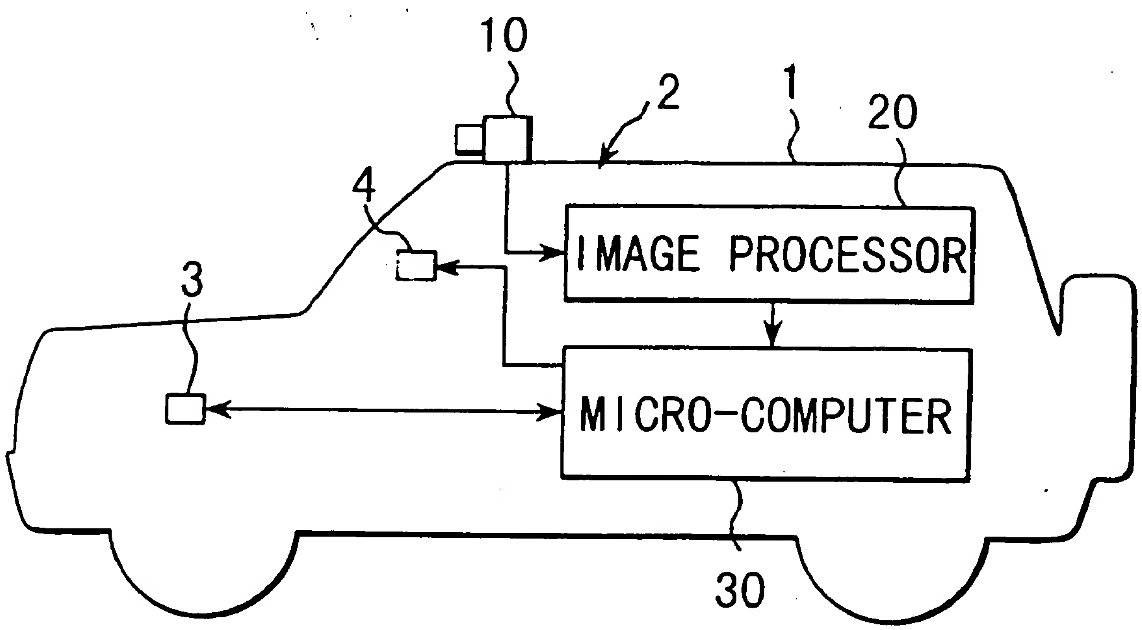


FIG.1

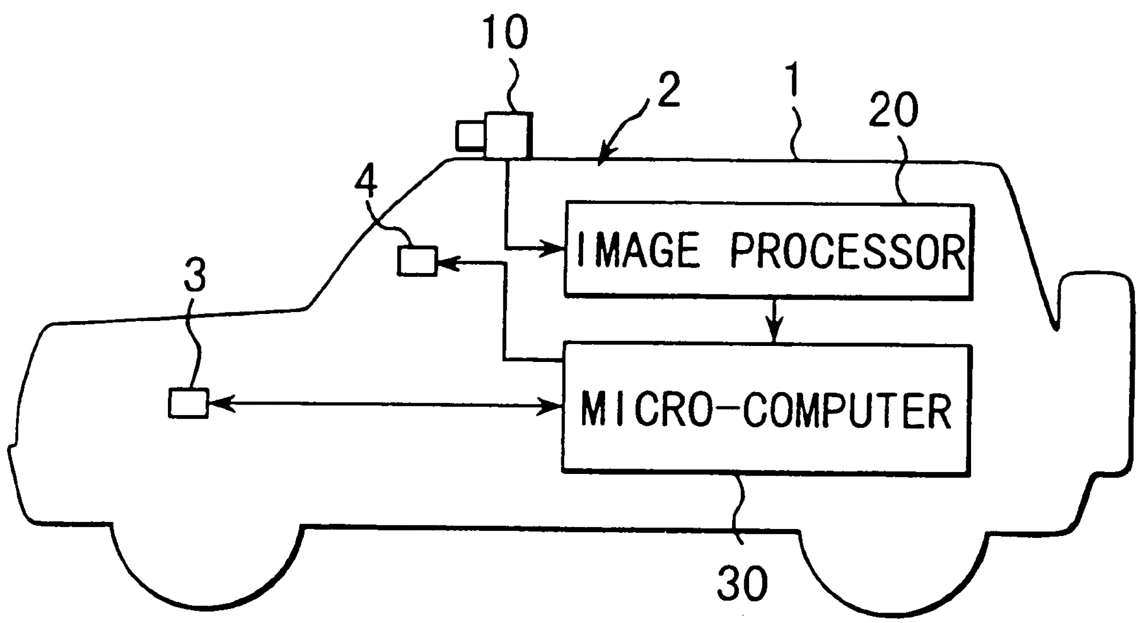


FIG.2

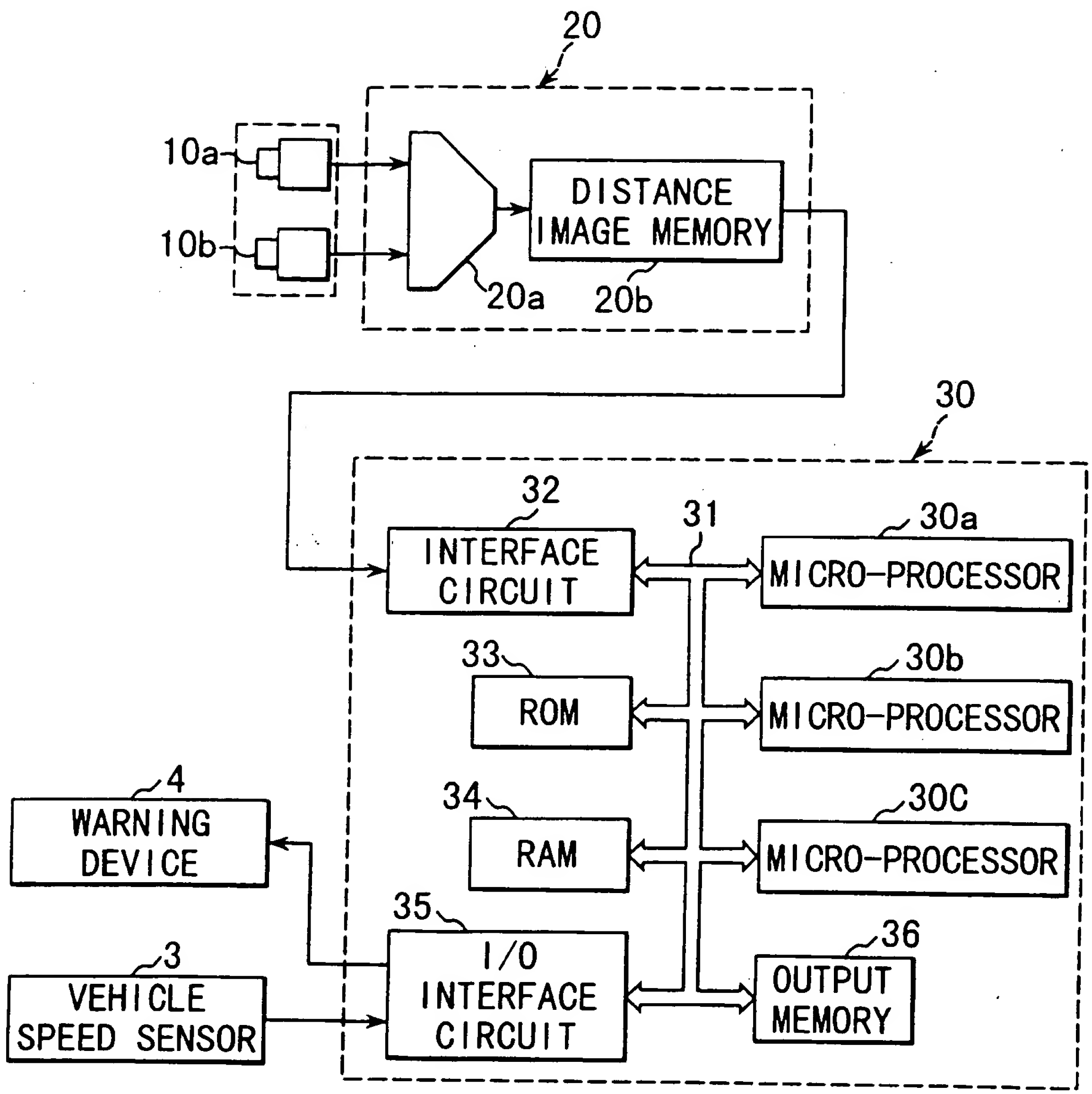

20
10a
10b
20a
20b
DISTANCE IMAGE MEMORY
30
32
31
30a
INTERFACE CIRCUIT
MICRO-PROCESSOR
33
ROM
30b
MICRO-PROCESSOR
4
WARNING DEVICE
34
RAM
30C
MICRO-PROCESSOR
35
36
3
I/O INTERFACE CIRCUIT
OUTPUT MEMORY
VEHICLE SPEED SENSOR

FIG.3

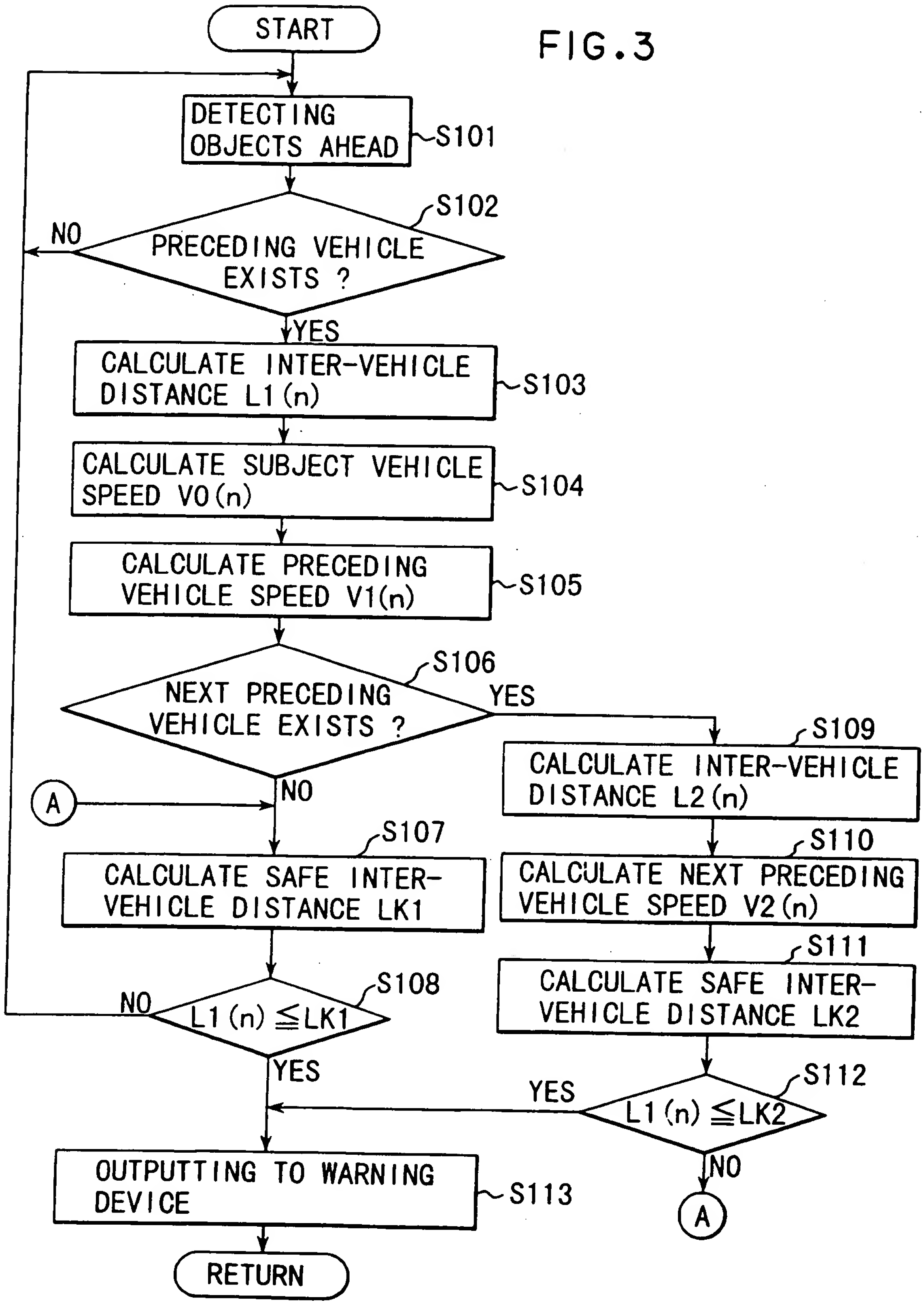

START
DETECTING OBJECTS AHEAD
S101
PRECEDING VEHICLE EXISTS ?
S102
NO
YES
CALCULATE INTER-VEHICLE DISTANCE L1 (n)
S103
CALCULATE SUBJECT VEHICLE SPEED V0 (n)
S104
CALCULATE PRECEDING VEHICLE SPEED V1(n)
S105
NEXT PRECEDING VEHICLE EXISTS ?
S106
YES
NO
A
CALCULATE SAFE INTER-VEHICLE DISTANCE LK1
S107
L1 (n) ≦LK1
S108
NO
YES
CALCULATE INTER-VEHICLE DISTANCE L2 (n)
S109
CALCULATE NEXT PRECEDING VEHICLE SPEED V2 (n)
S110
CALCULATE SAFE INTER-VEHICLE DISTANCE LK2
S111
L1 (n) ≦LK2
S112
YES
NO
A
OUTPUTTING TO WARNING DEVICE
S113
RETURN

FIG. 4

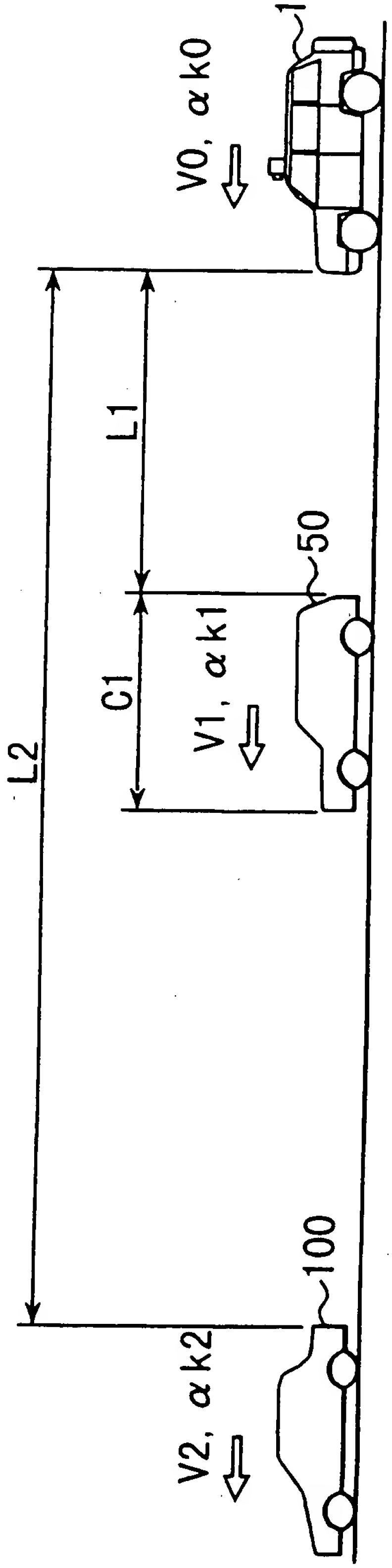


FIG.5

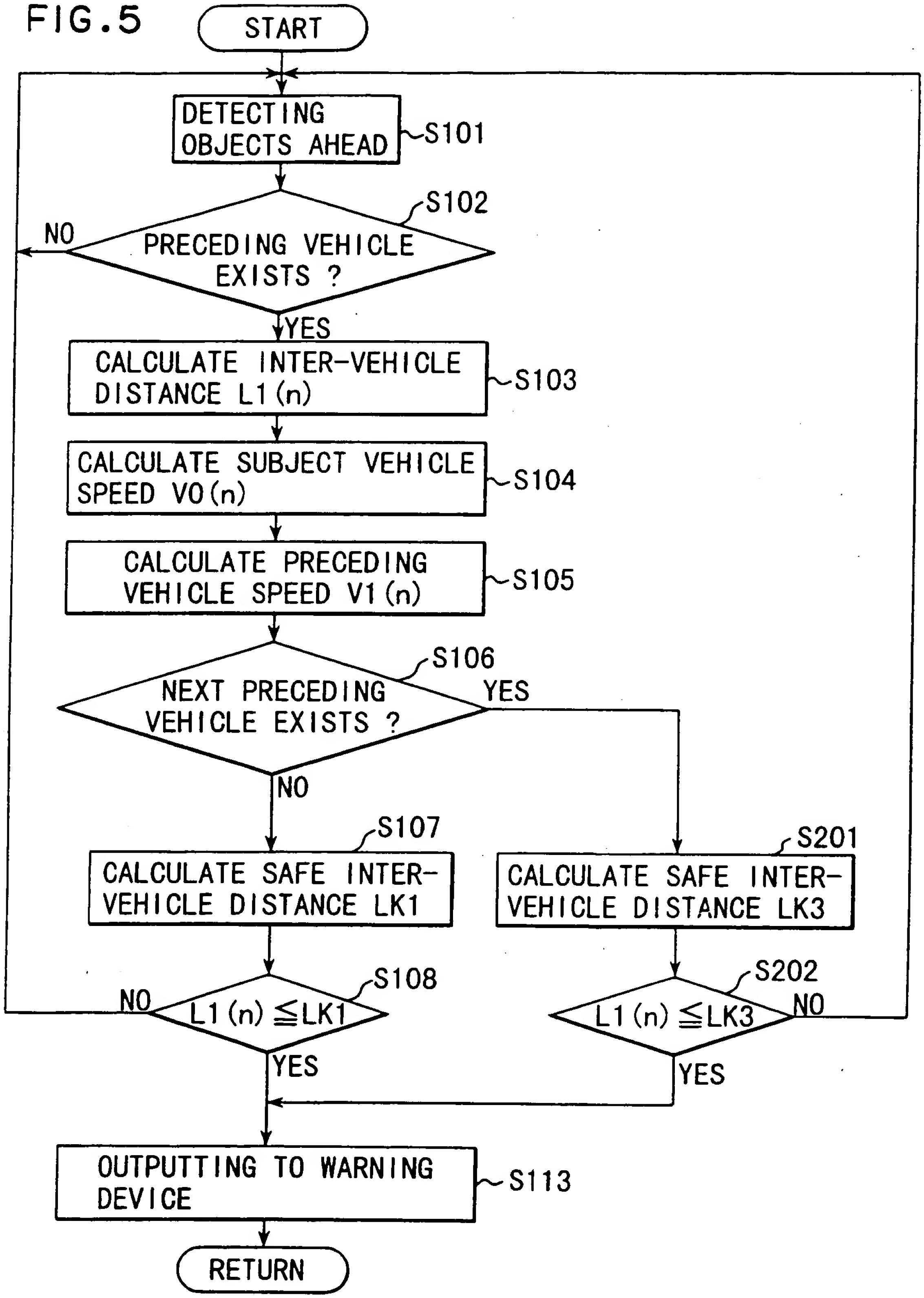
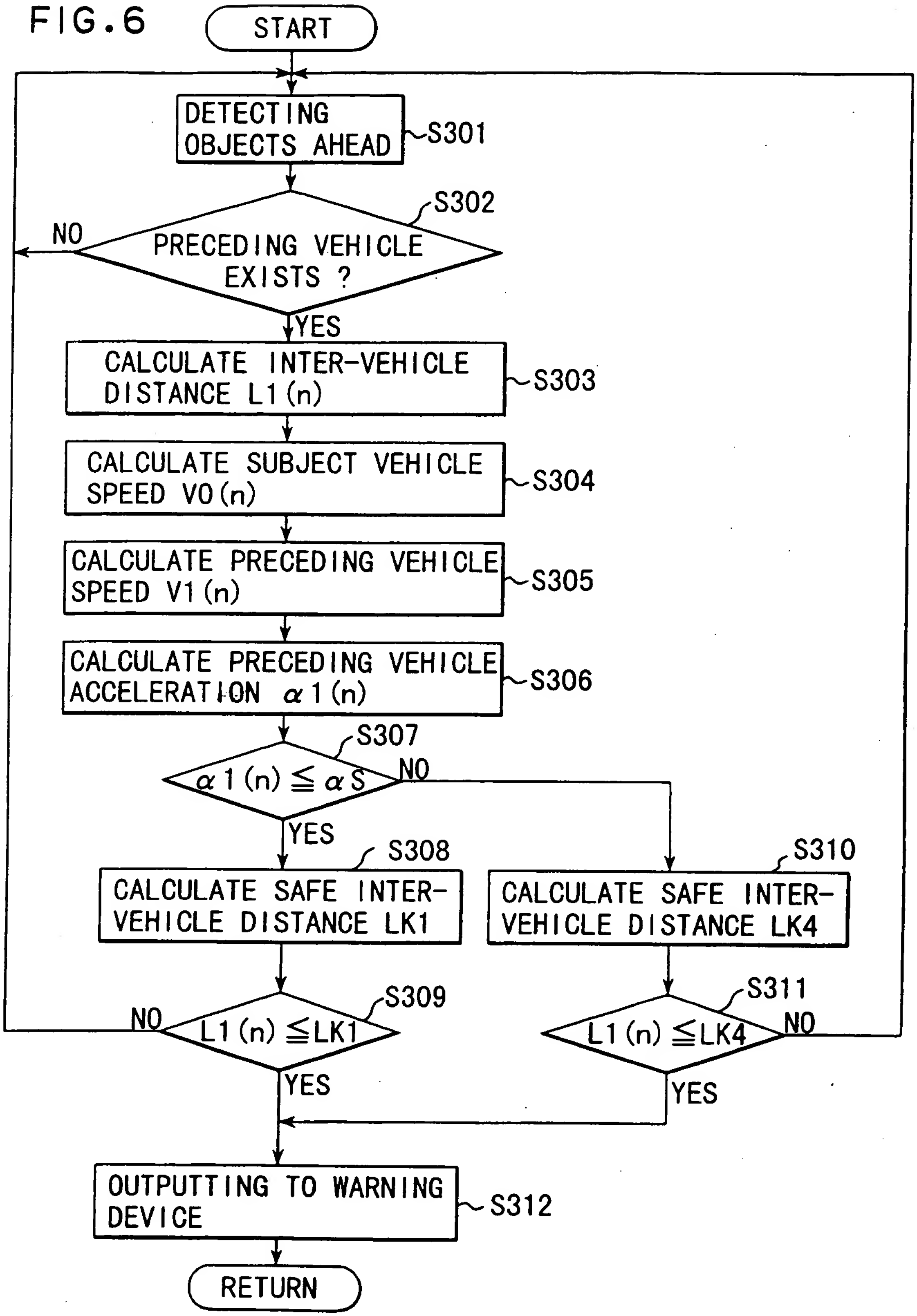

START
DETECTING OBJECTS AHEAD
S101
PRECEDING VEHICLE EXISTS ?
S102
NO
YES
CALCULATE INTER-VEHICLE DISTANCE L1 (n)
S103
CALCULATE SUBJECT VEHICLE SPEED V0 (n)
S104
CALCULATE PRECEDING VEHICLE SPEED V1 (n)
S105
NEXT PRECEDING VEHICLE EXISTS ?
S106
YES
NO
CALCULATE SAFE INTER-VEHICLE DISTANCE LK1
S107
CALCULATE SAFE INTER-VEHICLE DISTANCE LK3
S201
L1 (n) ≦LK1
S108
NO
YES
L1 (n) ≦LK3
S202
NO
YES
OUTPUTTING TO WARNING DEVICE
S113
RETURN

FIG.6


START
DETECTING OBJECTS AHEAD
S301
PRECEDING VEHICLE EXISTS ?
S302
NO
YES
CALCULATE INTER-VEHICLE DISTANCE L1(n)
S303
CALCULATE SUBJECT VEHICLE SPEED V0(n)
S304
CALCULATE PRECEDING VEHICLE SPEED V1(n)
S305
CALCULATE PRECEDING VEHICLE ACCELERATION α1(n)
S306
α1(n) ≦ αS
S307
NO
YES
CALCULATE SAFE INTER-VEHICLE DISTANCE LK1
S308
CALCULATE SAFE INTER-VEHICLE DISTANCE LK4
S310
L1(n) ≦ LK1
S309
NO
YES
L1(n) ≦ LK4
S311
NO
YES
OUTPUTTING TO WARNING DEVICE
S312
RETURN

VEHICLE COLLISION PREVENTING APPARATUS

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a vehicle collision preventing apparatus in which an obstacle is detected in a traveling direction of the vehicle and a judgment is made as to whether or not an own vehicle collides against the obstacle.

2. Prior Art

Recently, various approaches for safe driving have been attempted. One of these approaches is the development of an ASV (Advanced Safety Vehicle). The ASV includes techniques such as issuing alarm to a vehicle driver, stopping a vehicle by braking automatically, changing vehicle speeds automatically so as to maintain a proper inter-vehicle distance and the like by detecting obstacles ahead of the vehicle with TV cameras or laser beam-radar apparatus and the like and judging a possibility of collision with the obstacles.

As an example of this kind of technology, Journal of The Society of Automotive Engineers of Japan Vol. 43, No. 2, 1989, an article "Rear-end Collision Warning System using Laser for Heavy-duty Trucks" discloses a technology in which a vehicle speed of the preceding vehicle and a relative vehicle speed of the subject vehicle with respect to the preceding vehicle are calculated based on a vehicle speed of the subject vehicle and a distance between the subject vehicle and the preceding vehicle detected by a laser beam radar, and when the distance between two vehicles comes within a safe inter-vehicle distance calculated based on this relative vehicle speed, an alarm is sent out to warn a possible collision against the preceding vehicle.

However, this warning system is still insufficient because hazard is judged by observing only the preceding vehicle or only an obstacle ahead of the subject vehicle without taking other situations ahead of the preceding vehicle into consideration.

Assuming such a situation that the preceding vehicle comes to a sudden stop to avoid a collision with an obstacle, it is necessary to raise an alarm with a sufficient time margin. This requires to establish a very large inter-vehicle distance which may allow other vehicles to cut in between the subject vehicle and the preceding vehicle.

Further, since such a safe driving technique as noticing only the behavior of the preceding vehicle is fundamentally based on an assumption that the driver of the preceding vehicle always takes a reasonable behavior, it is impossible to expect a further safe driving.

SUMMARY OF THE INVENTION

Accordingly, the present invention is intended to obviate the disadvantages of the known arts.

It is an object of the present invention to provide a collision preventing apparatus capable of avoiding a collision with a preceding vehicle by watching not only an inter-vehicle distance between the self vehicle and the preceding vehicle but also an inter-vehicle distance between the self vehicle and a third vehicle running ahead of the preceding vehicle. In order to attain the object, the present invention comprises:

inter-vehicle distance calculating means for calculating an inter-vehicle distance between the self vehicle and the preceding vehicle;

safe inter-vehicle distance calculating means for calculating a safe-inter vehicle distance between the self

vehicle and the preceding vehicle in conjunction with an inter-vehicle distance between the self vehicle and the third vehicle running ahead of the preceding vehicle; and

hazard judging means for judging a hazard of collision with the preceding vehicle based on the inter-vehicle distance and the safe inter-vehicle distance.

BRIEF DESCRIPTION OF THE DRAWINGS

Preferred embodiments will be described with reference to accompanying drawings in which:

FIG. 1 is a schematic view of a collision preventing apparatus according to a first embodiment of the present invention;

FIG. 2 is a block diagram of a collision preventing apparatus according to a first embodiment of the present invention;

FIG. 3 is a flowchart showing a flow of control of a collision preventing apparatus according to a first embodiment of the present invention;

FIG. 4 is an explanatory view indicating a relationship between a self vehicle and a preceding vehicle and a relationship between a self vehicle and a next preceding vehicle;

FIG. 5 is a flowchart showing a flow of control of a collision preventing apparatus according to a second embodiment of the present invention; and

FIG. 6 is a flowchart showing a flow of control of a collision preventing apparatus according to a third embodiment of the present invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Referring now to FIG. 1, numeral 1 denotes a vehicle on which a collision preventing apparatus 2 is mounted in order to recognize an obstacle, a vehicle existing ahead of the subject vehicle or a next preceding vehicle which exists ahead of that preceding vehicle, to judge an impeding collision with those vehicles and to raise a warning.

The collision preventing apparatus 2 comprises a stereoscopic optical system 10 for imaging pictures of objects from two different positions, an image processor 20 for calculating three-dimensional distance distributions over an entire image of a pair of stereoscopic pictures taken by the stereoscopic optical system 10 according to a principle of triangulation, and a micro-computer 30 for processing distance distributions data sent from the image processor 20, for recognizing the shape of a road or a plurality of solid objects, for integratedly judging hazard with respect to a plurality of obstacles such as a preceding vehicle, a next preceding vehicle and the like and for warning a driver of an impending collision. Further, the micro-computer 30 is connected with sensors for detecting present vehicle running conditions such as a vehicle speed sensor 3 and the like and also connected with a warning device 4 composed of a buzzer, a display and the like.

As shown in FIG. 2, the stereoscopic optical system 10 is composed of a pair of left and right CCD cameras 10*a*, 10*b* using a solid-state image component such as a Charge Coupled Device (CCD). These CCD cameras 10*a*, 10*b*, as shown in FIG. 1, are disposed one for each on the left and right sides of the front roof of the vehicle 1 so as to be able to take an extensive view of objects ahead of the preceding vehicle as well as ahead of the self vehicle.

The image processor 20, as shown in FIG. 2, comprises a distance detecting circuit 20*a* and a distance image memory

20*b*. In the distance detecting circuit 20*a*, a small region imaging the same object is searched from two stereoscopic pictures taken by the stereoscopic optical system **10**, respectively and the distance to the object is calculated from the amount of deviation between these two small regions. In the distance image memory **20*b***, distance distributions data having a form of the image picture are memorized.

Further, the micro-computer **30** comprises a micro-processor **30*a*** whose function is mainly to detect configurations of roads, a micro-processor **30*b*** whose function is mainly to detect solid objects, a micro-processor **30*c*** whose function is to judge hazard of an impending collision with the preceding vehicle, and a bus line **31** connected in parallel with these micro-processors **30*a***, **30*b***, **30*c***.

Further, within the micro-computer **30**, the bus line **31** is connected with an interface circuit **32** which is connected to the distance image memory **20*b***, a ROM **33** for storing a control program, a RAM **34*b*** for memorizing miscellaneous parameters needed for calculations, an input-and-output (I/O) interface which is connected to the vehicle speed sensor **3** and the warning device **4**, and an output memory **36**.

In the micro-processor **30*a*** for detecting configurations of roads, first actual lane markers of a road are extracted from three-dimensional positional information contained in the distance image which is stored in the distance image memory **20*b*** and then the configuration of the road is recognized by modifying a road model stored therein based on the actual lane markers.

Further, in the micro-processor **30*b*** for detecting objects, objects on a road are detected as follows:

First, the distance image is divided into a plurality of three-dimensional lattices and only solid objects data having a possibility of obstructing the running of the subject vehicle are selected from respective lattices. Then, distances to the objects are calculated. If the difference of the detected distance to two adjacent objects is smaller than a specified value, these two objects are deemed as the same object. On the other hand, if the difference of the detected distance to two adjacent objects is larger than a specified value, these two objects are deemed as the different objects, respectively. Thus, repeating these processes, an outline of the detected object is extracted.

The formation of the distance image by the image processor **20** and the processes of detecting the road configuration and objects by the micro-processors **30*a***, **30*b*** are described in detail in Japanese Patent Applications Laid-open Toku-Kai-Hei 5-265547 and Toku-Kai-Hei 6-177236 filed by the inventor of the present invention.

Further, in the micro-processor **30*c*** for judging hazard of an impending collision with the preceding vehicle, first a safe inter-vehicle distance between the subject vehicle and the preceding vehicle is calculated, and when the inter-vehicle distance becomes smaller than a safe inter-vehicle distance, an alarm is outputted to the warning device **4**. Further, according to the present invention, in addition to this, in case where a next preceding vehicle exists ahead of the preceding vehicle, the safe inter-vehicle distance between the subject vehicle and the preceding vehicle is calculated taking an inter-vehicle distance or a relative vehicle speed between the subject vehicle and the next preceding vehicle into consideration. In this case, when the inter-vehicle distance between the subject vehicle and the preceding vehicle becomes smaller than a safe inter-vehicle distance, the warning device **4** raises an alarm to urge the driver to apply brakes (not shown). Thus, the subject vehicle can secure a safe driving, even when the next preceding vehicle applies an emergency brake. Further, this function can be more effective by interlocking the warning device with an automatic brake apparatus (not shown)and the like.

Next, the collision preventing process of the microprocessor **30** will be described according to a flowchart shown in FIG. 3.

Referring to FIG. 3, the subject vehicle **1** runs after the preceding vehicle **50** with an inter-vehicle distance L1 and further a next preceding vehicle **100** runs ahead of the subject vehicle with an inter-vehicle distance L2. In this example, the next preceding vehicle may be replaced with a parked vehicle or may be a pedestrian walking across the road.

At a step **S101**, the data of solid objects extracted from the distance image are read and at a step **S102** (hereinafter referred to as "S number") it is checked whether or not a preceding vehicle exists in the running direction of the vehicle. If there is no preceding vehicle, the program returns to **S101** and if a preceding vehicle exists, the program goes to **S103** where the inter-vehicle distance $L1_{(n)}$ between the subject vehicle and the preceding vehicle is calculated. The previously calculated inter-vehicle distance is stored as $L1_{(n-1)}$. Here, the subscript (n) indicates a presently obtained value and the subscript (n−1) depicts a previously obtained value.

Next, the program goes to **S104** where a vehicle speed V0 of the subject vehicle **1** is calculated. Then, at **S105** a vehicle speed $V1_{(n)}$ of the preceding vehicle **50** is calculated according to the following equation based on a time-versus change of the present inter-vehicle distance $L1_{(n)}$ with respect to the previous inter-vehicle distance $L1_{(n-1)}$ and the present vehicle speed $V0_{(n)}$ of the subject vehicle **1**:

$$V1_{(n)}=(L1_{(n)}-L1_{(n-1)})/\Delta t+V0_{(n)} \tag{1}$$

where Δt is a time interval for measurement and calculation.

After that, the program goes to **S106** where it is checked from the data of extracted solid objects whether or not a next preceding vehicle exists. If there is no next preceding vehicle, the program goes from **S106** to **S107** where a safe inter-vehicle distance LK1 between the subject vehicle and the preceding vehicle is calculated

The safe inter-vehicle distance LK1 is calculated according to the following equation:

$$LK1=-V1_{(n)}^2/(2\cdot\alpha_{k11})+V0_{(n)}^2/(2\cdot\alpha_{k0})+V0_{(n)}\cdot T1+L0 \tag{2}$$

where α_{k11} is a deceleration of the preceding vehicle when the preceding vehicle applies a brake, α_{k0} is a deceleration of the subject vehicle when the subject vehicle applies a brake to avoid collision, T1 is a dead time of the subject vehicle and L0 is a space margin between both vehicles after both stop. In the equation (2) the paragraph "$V1_{(n)}^2/(2\cdot\alpha_{k11})$" is a braking distance of the preceding vehicle when the preceding vehicle is braked with a deceleration α_{k11} at the vehicle speed $V1_{(n)}$ and the paragraph "$V0_{(n)}^2/(2\cdot\alpha_{k0})$" is a braking distance of the subject vehicle when the subject vehicle is braked with a deceleration α_0 at the vehicle speed $V1_{(n)}$.

The deceleration α_{k11} is a value which has been established beforehand based on the assumption that the precedent vehicle will apply an emergency brake and the deceleration α_{k0} is a value which has been established in consideration of the brake efficiency of the subject vehicle. Further, the dead time T1 is determined taking a driver's response time into consideration. The space margin LO

maybe determined in accordance with the magnitude of deceleration, for example, establishing the space margin so as to be larger as deceleration becomes large.

After the safe inter-vehicle LK1 is calculated at S107, the program goes to S108 where the safe inter-vehicle distance LK1 is compared with the present inter-vehicle distance $L1_{(n)}$. If the present inter-vehicle distance $L1_{(n)}$ is larger than the safe inter-vehicle distance LK1, the program returns to S101. If the present inter-vehicle distance $L1_{(n)}$ is smaller than or equal to the safe inter-vehicle distance LK1, the program goes to S113 where a warning signal is outputted to the warning device 4 to warn the vehicle driver of an imminent collision, and then the program leaves the routine.

On the other hand, if it is judged at S106 that a next preceding vehicle exists, the program skips to S109 where an inter-vehicle distance $L2_{(n)}$ between the next preceding vehicle and the subject vehicle is calculated. Then, at S110, a vehicle speed $V2_{(n)}$ of the next preceding vehicle 100 is calculated according to the following equation based on a time-versus change of the present inter-vehicle distance $L2_{(n)}$ with respect to the previous inter-vehicle distance $L2_{(n-1)}$ and the present vehicle speed $V0_{(n)}$ of the subject vehicle 1:

$$V2_{(n)}=(L2_{(n)}-L2_{(n-1)})/\Delta t+V0_{(n)} \quad (3)$$

Then, the program goes to S111 where a safe intervehicle distance LK2 between the subject vehicle and the preceding vehicle is calculated taking the existence of the next preceding vehicle into consideration. That is to say, as shown in FIG. 4, assuming such a situation that the driver of the preceding vehicle 50 makes an abnormal access to the next preceding vehicle 100 and applies an emergency brake or swerves the vehicle to avoid a collision, the safe inter-vehicle distance LK2 is calculated according to the following equation (4). In calculating the safe inter-vehicle distance LK2, the braking distance "$V1_{(n)}^2/(2\cdot\alpha_{k11})$" of the preceding vehicle 50 is replaced with the braking distance "$V2_{(n)}^2/(2\cdot\alpha_{k2})$" of the next preceding vehicle 100:

$$LK2=-V2_{(n)}^2/(2\cdot\alpha_{k2})+V0_{(n)}^2/(2\cdot\alpha_{k0})+V0_{(n)}\cdot T1+L0+C1 \quad (4)$$

where C1 is a body length of the preceding vehicle.

In this case, the paragraph "$V2_{(n)}^2/(2\cdot\alpha_{k2})$" which means the braking distance in the equation (4) is established to be 0 when the object detected ahead of the preceding vehicle is not a running vehicle but a parked vehicle or a pedestrian and the deceleration α_{k2} of the subject vehicle is established such that the paragraph "$V0_{(n)}^2/(2\cdot\alpha_{k0})+V0_{(n)}\cdot T1+L0+C1$" becomes smaller than the distance $L2_{(n)}$ from the subject vehicle to the object.

Next, the program goes from S111 to S112 where the present inter-vehicle distance $L1_{(n)}$ is compared with the safe inter-vehicle distance LK2 in a case where the next preceding vehicle exists. If the present inter-vehicle distance $L1_{(n)}$ is larger than the safe inter-vehicle distance LK2, the program skips to S107 where the present inter-vehicle distance $L1_{(n)}$ is compared with the safe inter-vehicle distance LK1 in a case where the next preceding vehicle does not exist. On the other hand, if the present inter-vehicle distance $L1_{(n)}$ is equal to or smaller than the safe inter-vehicle distance LK2 in case where the next preceding vehicle exists, a warning signal is outputted to the warning device 4 at S113 and the program leaves the routine.

Thus, according to the embodiment, even in such a case where the driver of the preceding vehicle does not take an appropriate inter-vehicle distance between his own vehicle and a vehicle running ahead of him and as a result he applies an emergency brake, the subject vehicle can be operated keeping a safe inter-vehicle distance between the subject vehicle and the preceding vehicle.

FIG. 5 is a flowchart showing a flow of control of a collision preventing apparatus according to a second embodiment. The feature of the second embodiment is that the safe inter-vehicle distance is calculated by taking a dead time due to the delay of hazard recognition of a driver of the preceding vehicle into consideration under such a situation as being unable to measure an accurate inter-vehicle distance between the subject vehicle and the next preceding vehicle.

That is to say, in case where the preceding vehicle is so huge that the visual fields of the CCD cameras 10*a*, 10*b* are blocked, only chance to recognize the next preceding vehicle is when these vehicles run on curved roads or when either of these gets out of the lane on the left or right side.

Accordingly, there is a case where it is impossible to measure an accurate distance to the next preceding vehicle although the next preceding vehicle is recognized ahead. Under this situation, the safe inter-vehicle distance L2 in case where the next preceding vehicle exists can not be used and another safe inter-vehicle distance must be prepared.

FIG. 5 is a flowchart corrected for this purpose and steps S109 to S112 of the first embodiment have been replaced with new steps S201 and S202.

Namely, when the next preceding vehicle is detected at S106, the program skips to S201 where a safe inter-vehicle distance LK3 is calculated according to the following equation (5) based on the vehicle speed $V0_{(n)}$ of the subject vehicle and the vehicle speed $V1_{(n)}$ of the preceding vehicle in consideration of the existence of the next preceding vehicle:

$$LK3=-V1_{(n)}^2/(2\cdot\alpha_{k12})+V0_{(n)}^2/(2\cdot\alpha_{k0})+V0_{(n)}\cdot(T1+T2)+L0 \quad (5)$$

In the above equation, T2 is a dead time of the preceding vehicle determined taking a delay of a driver's response time into consideration. Therefore, the paragraph "$V0_{(n)}\cdot(T1+T2)$" is an invalid running distance of the subject vehicle.

Further, the deceleration α_{k12} of the preceding vehicle may be established to be a value similar to the deceleration in case where there is no next preceding vehicle or alternatively it may be established to be a larger value on the safer side.

After the safe inter-vehicle distance LK3 is calculated at S201, the program goes to S202 where the safe inter-vehicle distance LK3 is compared with the present inter-vehicle distance $L1_{(n)}$. If the present inter-vehicle distance $L1_{(n)}$ is larger than the safe inter-vehicle distance LK3, the program returns to S101. If the present inter-vehicle distance $L1_{(n)}$ is equal to or smaller than the inter-vehicle distance LK3, the program goes to S113 where a warning signal is outputted to the warning device 4 and then the program leaves the routine.

Thus, according to this embodiment, since an adequate inter-vehicle distance is taken, an unexpected accident can be avoided even when a driver of the preceding vehicle having an insufficient inter-vehicle distance to the next preceding vehicle applies an emergency brake.

FIG. 6 is a flowchart showing a flow of control of the collision preventing apparatus according to a third embodiment. In this embodiment, the safe inter-vehicle distance is established according to the acceleration state of the preceding vehicle taking a delay of recognition or a delay of judgment of the driver of the subject vehicle into consideration.

In the flowchart of FIG. 6, steps S301 to S305 are the same steps as in the flowchart of FIG. 3. After the present

vehicle speed $V1_{(n)}$ of the preceding vehicle is calculated, at S306 an acceleration $\alpha 1_{(n)}$ of the preceding vehicle is calculated in accordance with the following equation (6):

$$\alpha 1_{(n)}=(V1_{(n-1)}-V1_{(n)})/\Delta t \tag{6}$$

Then, the program steps to S307 where it is judged whether or not the present acceleration $\alpha 1_{(n)}$ of the preceding vehicle is smaller than a specified value as which is a threshold value for foreseeing hazard after the preceding vehicle is accelerated. When $\alpha 1_{(n)} \leqq \alpha S$, the program goes from S307 to S308 where the safe inter-vehicle distance LK1 described is calculated according to the equation (2) of the first embodiment. That is to say, in this case, the safe inter vehicle distance takes the same value as in the case where the next preceding vehicle is not detected.

Further, the program goes to S309 where, as in the same manner as the first embodiment, the present inter-vehicle distance $L1_{(n)}$ is compared with the safe inter-vehicle distance LK1. If the present inter-vehicle distance $L1_{(n)}$ is larger than the safe inter-vehicle distance LK1, the program returns to the step S301. On the other hand, if the present inter-vehicle distance $L1_{(n)}$ is equal to or smaller than the safe inter-vehicle distance LK1, an alarm signal is outputted to the warning device 4 and the program leaves the routine.

When $\alpha 1_{(n)} > \alpha S$ at S307, the program is diverted from S307 to S310 where a safe inter-vehicle distance LK4 is calculated according to the following equation (7). The safe inter-vehicle distance LK4 is a distance value which is determined assuming a hazard when the preceding vehicle is decelerated suddenly after acceleration.

$$LK4=-V1_{(n)}^2/(2\cdot\alpha_{k13})+V0_{(n)}^2/(2\cdot\alpha_{k0})+V0_{(n)}\cdot(T1+\Delta T)+L0 \tag{7}$$

In the equation (7), ΔT is a dead time taking account of a belief of the driver of the subject vehicle. Generally, the driver tends to believe it to be safe when the preceding vehicle starts to be accelerated, although there is a possibility that the preceding vehicle may be braked suddenly to avoid a collision with obstacles or to make a turn to the left or right. Under these situations, it takes a some amount of time until the driver notices hazard and starts to depress the brake pedal for avoiding hazard. Accordingly, the paragraph "$V0_{(n)}\cdot(T1+\Delta T)$" is an invalid running distance when taking this "driver's belief" into consideration. Further, the paragraph "$V1_{(n)}^2/(2\cdot\alpha_{k13})$" is a braking distance of the preceding vehicle when a brake is applied with a deceleration α_{k13} at the vehicle speed V1(n) and the paragraph "$V0_{(n)}^2/(2\cdot\alpha_{k0})$" is a braking distance of the subject vehicle when a brake is applied with a deceleration α_{k0} at the vehicle speed $V0_{(n)}$.

The dead time ΔT may be varied according to the vehicle speed $V1_{(n)}$ of the preceding vehicle, the vehicle speed $V0_{(n)}$ of the subject vehicle, the acceleration $\alpha_{(n)}$ of the preceding vehicle and the like. Further, the deceleration α_{k13} may be established to be a large value in place of introducing the dead time ΔT.

After calculating the safe inter-vehicle distance LK4 at S311, the program goes to S311 where it is judged whether or not the present inter-vehicle distance $L1_{(n)}$ is compared with the safe inter-vehicle distance LK4. If the present inter-vehicle distance $L1_{(n)}$ is larger than the safe inter-vehicle distance LK4, the program returns to S301 and If the present inter-vehicle distance $L1_{(n)}$ is equal to or smaller than the safe inter-vehicle distance LK4, the program goes to S312 where a warning signal is outputted to the warning device 4 and leaves the routine.

Since the collision preventing apparatus according to the embodiment allows the vehicle to have a safe inter-vehicle distance in case for an emergency brake of the preceding vehicle, it is effective especially when the subject vehicle repeats a stop-and-go or with a short inter-vehicle distance to the preceding vehicle. Further the collision preventing apparatus is also effective when those vehicles run at low speeds with a short inter-vehicle distance, because in situations like these accidents tend to occur frequently.

Further, the embodiments described hereinbefore have exemplified the collision preventing apparatus having stereoscopic cameras for imaging objects ahead of the subject vehicle, however as alternative modes of the invention, in place of the stereoscopic cameras, a scanning type laser beam-radar or the combination of the scanning type laser beam-radar and a single-eye camera may be employed to recognize objects.

In summary, according to the present invention, since the collision preventing apparatus is constituted such that the inter-vehicle distance between the self vehicle and the preceding vehicle is calculated is compared with the safe inter-vehicle distance calculated in conjunction with situations ahead of the preceding vehicle as well as the preceding vehicle and based on the result of the comparison it is judged whether or not the self vehicle has a possibility of collision with the preceding vehicle, not only the vehicle can obtain an overall safety with regard to a plurality of objects ahead such as the preceding vehicle and the next preceding vehicle, but also the vehicle can enjoy a smooth and safe driving without disturbing a stream of traffics.

While the presently preferred embodiments of the present invention have been shown and described, it is to be understood that these disclosures are for the purpose of illustration and that various changes and modifications may be made without departing from the scope of the invention as set forth in the appended claim.

What is claimed is:

1. A collision preventing apparatus of a subject vehicle for preventing collision with a preceding vehicle which is traveling in front of said subject vehicle, comprising:

actual inter-vehicle distance detecting means for detecting a first actual inter-vehicle distance between said subject vehicle and said preceding vehicle and a second actual inter-vehicle distance between said subject vehicle and an object existing ahead of said preceding vehicle;

safe inter-vehicle distance calculating means for calculating a first safe inter-vehicle distance between said subject vehicle and said preceding vehicle and a second safe inter-vehicle distance between said subject vehicle and said object, in accordance with a braking distance and a dead time before braking of said subject vehicle; and

hazard judging means for judging a hazard of collision of said subject vehicle with said preceding vehicle in the case that said second actual inter-vehicle distance becomes smaller than said second safe inter-vehicle distance even when said first actual inter-vehicle distance is larger than said safe inter-vehicle distance.

2. A collision preventing apparatus of a subject vehicle for preventing a collision with a preceding vehicle which is traveling in front of said subject vehicle, comprising:

actual inter-vehicle distance detecting means for detecting an actual inter-vehicle distance between said subject vehicle and said preceding vehicle;

safe inter-vehicle distance calculating means for alternatively calculating a first safe inter-vehicle distance and

a second safe inter-vehicle distance between said subject vehicle and said preceding vehicle, depending on whether an object exists ahead of said preceding vehicle, said second safe inter-vehicle distance being calculated taking account of a dead time before braking of said preceding vehicle in addition to a braking distance and a dead time before braking of said subject vehicle which are used to calculate said first safe inter-vehicle distance; and

hazard judging means for judging a hazard of collision of said subject vehicle with said preceding vehicle in the case that said actual inter-vehicle distance becomes smaller than alternatively one of said first and second safe inter-vehicle distances.

3. A collision preventing apparatus of a subject vehicle for preventing a collision with a preceding vehicle which is traveling in front of said subject vehicle, comprising:

actual inter-vehicle distance detecting means for detecting an actual inter-vehicle distance between said subject vehicle and said preceding vehicle;

safe inter-vehicle distance calculating means for alternatively calculating a first safe inter-vehicle distance and a second safe inter-vehicle distance between said subject vehicle and said preceding vehicle, depending on whether the magnitude of acceleration of said preceding vehicle exceeds a threshold value, said second safe inter-vehicle distance being set longer than said first safe inter-vehicle distance; and

hazard judging means for judging a hazard of collision of said subject vehicle with said preceding vehicle in the case that said actual inter-vehicle distance becomes smaller than alternatively one of said first and second safe inter-vehicle distances.

* * * * *

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Miller et al.

(10) **Patent No.: US 6,442,484 B1**
(45) **Date of Patent: Aug. 27, 2002**

(54) **METHOD AND APPARATUS FOR PRE-CRASH THREAT ASSESSMENT USING SPHEROIDAL PARTITIONING**

(75) Inventors: **Ronald Hugh Miller**, Saline; **Irving Tolvo Salmeen**, Ann Arbor; **Anya Lynn Tascillo**, Belleville, all of MI (US)

(73) Assignee: **Ford Global Technologies, Inc.**, Dearborn, MI (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/683,593**

(22) Filed: **Jan. 23, 2002**

(51) **Int. Cl.**[7] **G05D 1/02**

(52) **U.S. Cl.** **701/301**; 701/200; 340/990; 340/995

(58) **Field of Search** 701/301, 200, 701/208; 340/990, 995; 180/167

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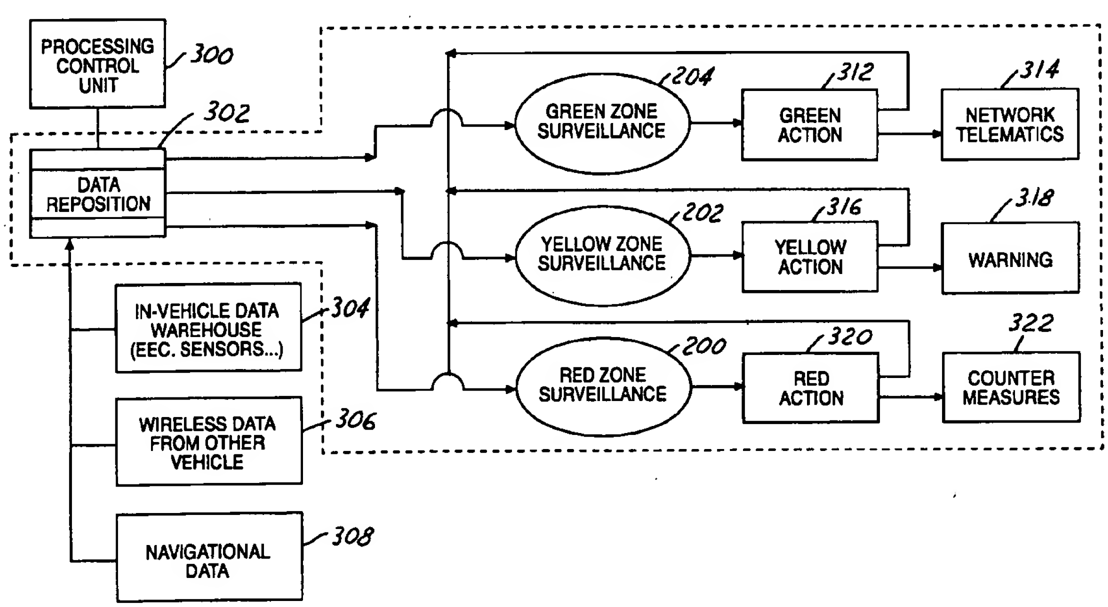
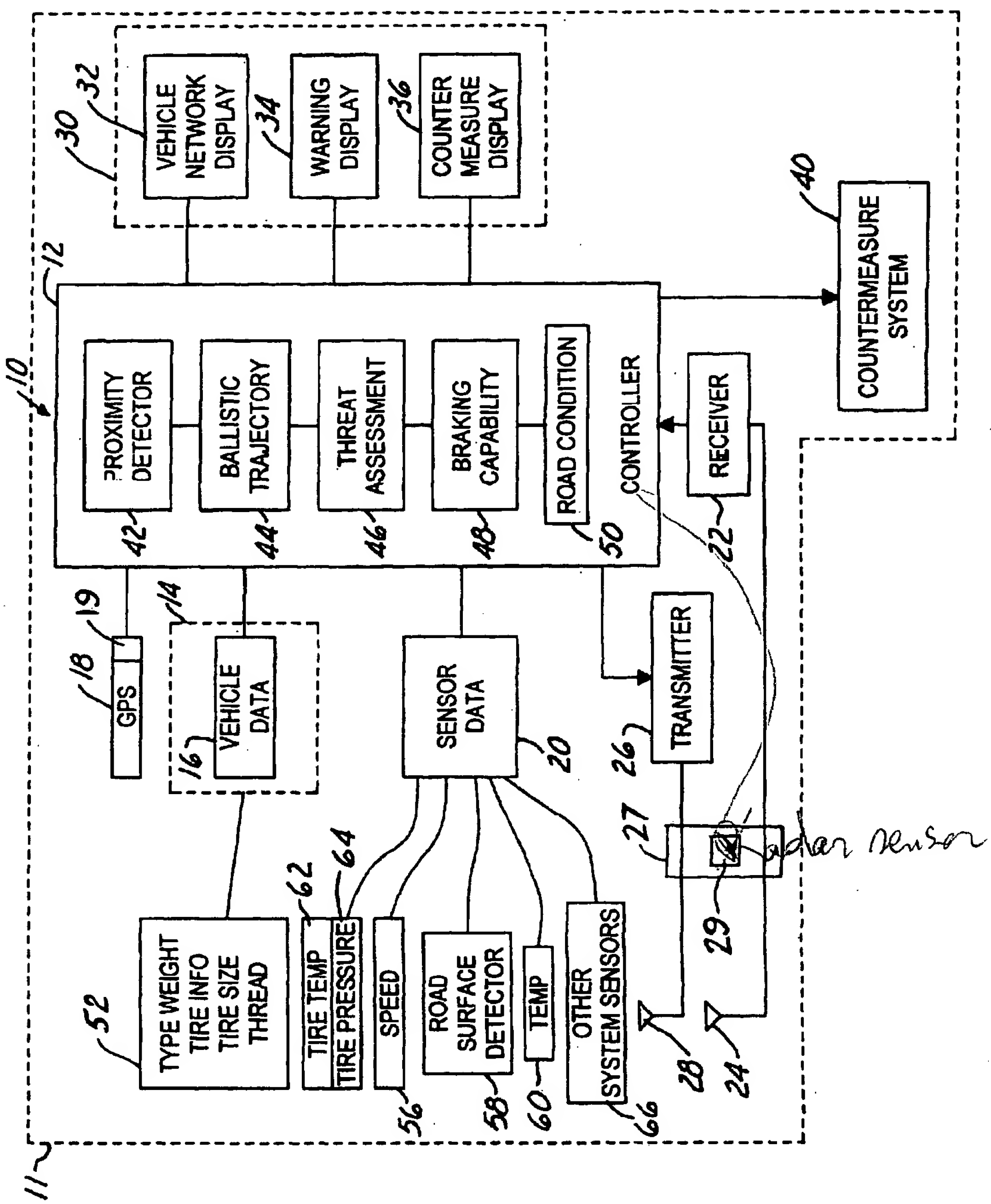
Primary Examiner—William A. Cuchlinski, Jr.
Assistant Examiner—Marthe Y. Marc-Coleman
(74) *Attorney, Agent, or Firm*—Frank A. MacKenzie

(57) **ABSTRACT**

A method for operating a pre-crash sensing system for a vehicle having an object detecting system and an associated data storage. The method includes partitioning the vehicle operating environment into a plurality of zones wherein each zone represents a different area surrounding the vehicle. In response to detecting an object within any one of the zones, the method activates the zone, and modifies an state of the object detection system and the contents of,the data storage as a function. the active zone. In one embodiment, three zones are disclosed wherein each zone represents a spheroidal area surrounding the vehicle. When the furthest zone is active, all data within the data storage is given approximately equal processing priority. When the middle zone is active, the content of the data storage is modified to prioritize data regarding the detected object for processing. Finally, when the nearest zone is active, the content of the data storage is further modified to provide highest priority to data regarding the detected object.

20 Claims, 5 Drawing Sheets




VEHICLE NETWORK DISPLAY
WARNING DISPLAY
COUNTER MEASURE DISPLAY
COUNTERMEASURE SYSTEM
PROXIMITY DETECTOR
BALLISTIC TRAJECTORY
THREAT ASSESSMENT
BRAKING CAPABILITY
ROAD CONDITION
CONTROLLER
RECEIVER
GPS
VEHICLE DATA
SENSOR DATA
TRANSMITTER
radar sensor
TYPE WEIGHT TIRE INFO TIRE SIZE THREAD
TIRE TEMP
TIRE PRESSURE
SPEED
ROAD SURFACE DETECTOR
TEMP
OTHER SYSTEM SENSORS
10
11
12
14
16
18
19
20
22
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26
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28
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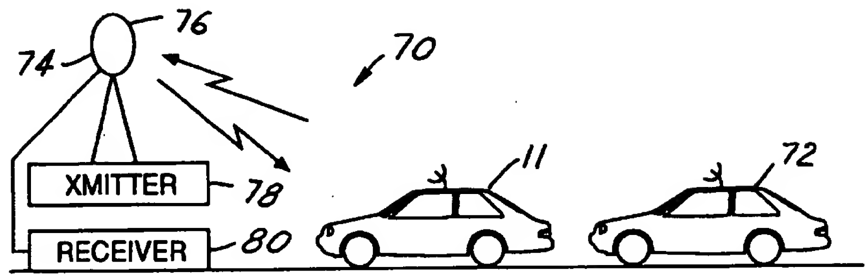
FIG. 1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70
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XMITTER
78
RECEIVER
80

FIG. 2

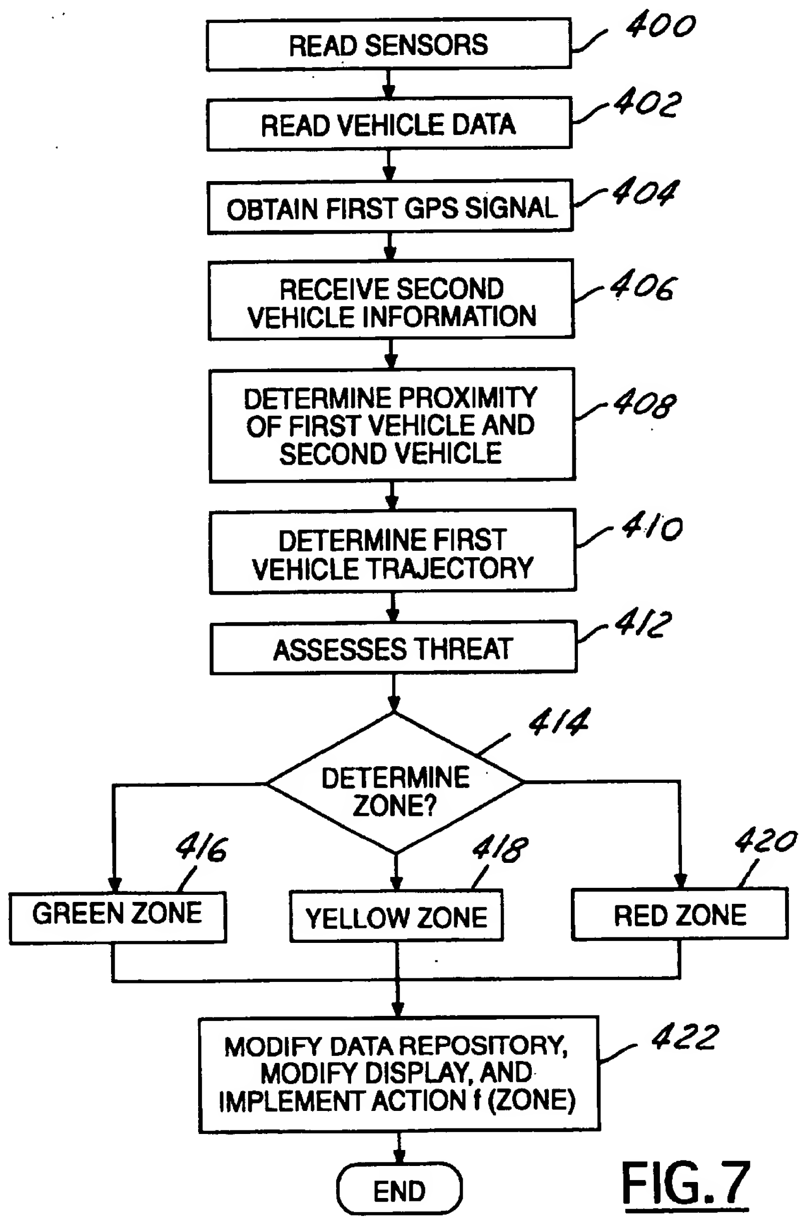

READ SENSORS
400
READ VEHICLE DATA
402
OBTAIN FIRST GPS SIGNAL
404
RECEIVE SECOND VEHICLE INFORMATION
406
DETERMINE PROXIMITY OF FIRST VEHICLE AND SECOND VEHICLE
408
DETERMINE FIRST VEHICLE TRAJECTORY
410
ASSESSES THREAT
412
DETERMINE ZONE?
414
416
418
420
GREEN ZONE
YELLOW ZONE
RED ZONE
MODIFY DATA REPOSITORY, MODIFY DISPLAY, AND IMPLEMENT ACTION f (ZONE)
422
END

FIG. 7

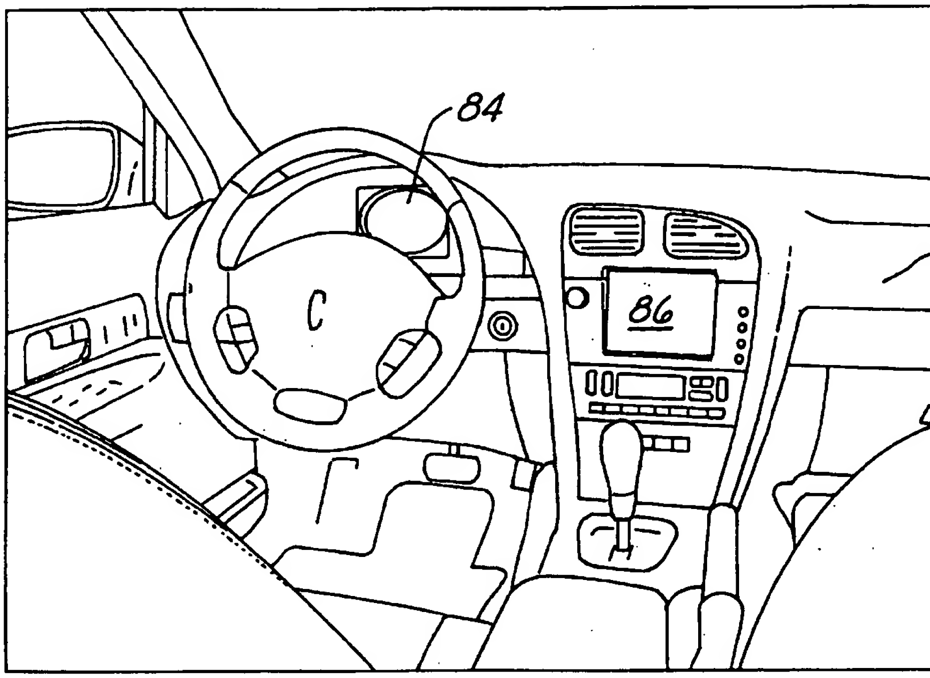
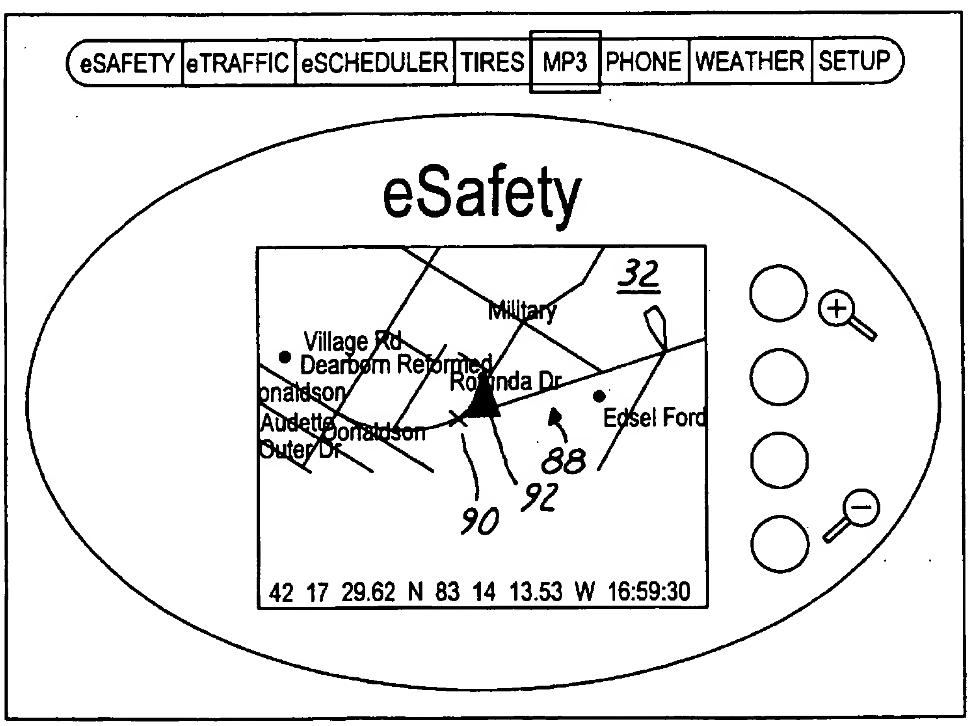

84
82
86

FIG. 3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eTRAFFIC
eSCHEDULER
TIRES
MP3
PHONE
WEATHER
SETUP
eSafety
32
Military
Village Rd
Dearborn Reformed
onaldson
Rotunda Dr
Audette
Donaldson
Outer Dr
Edsel Ford
88
92
90
42 17 29.62 N 83 14 13.53 W 16:59:30

FIG. 4

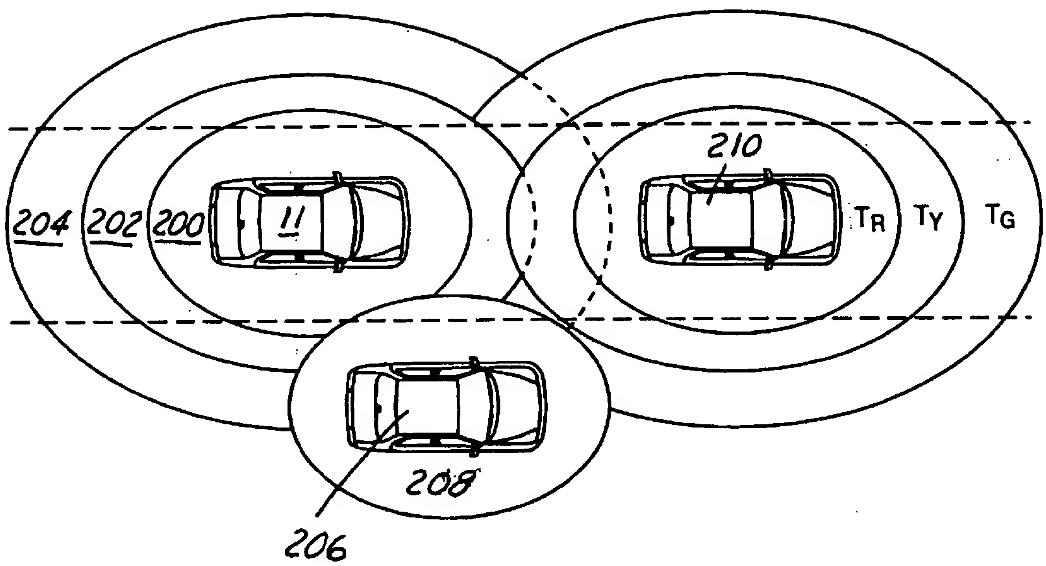

FIG. 5

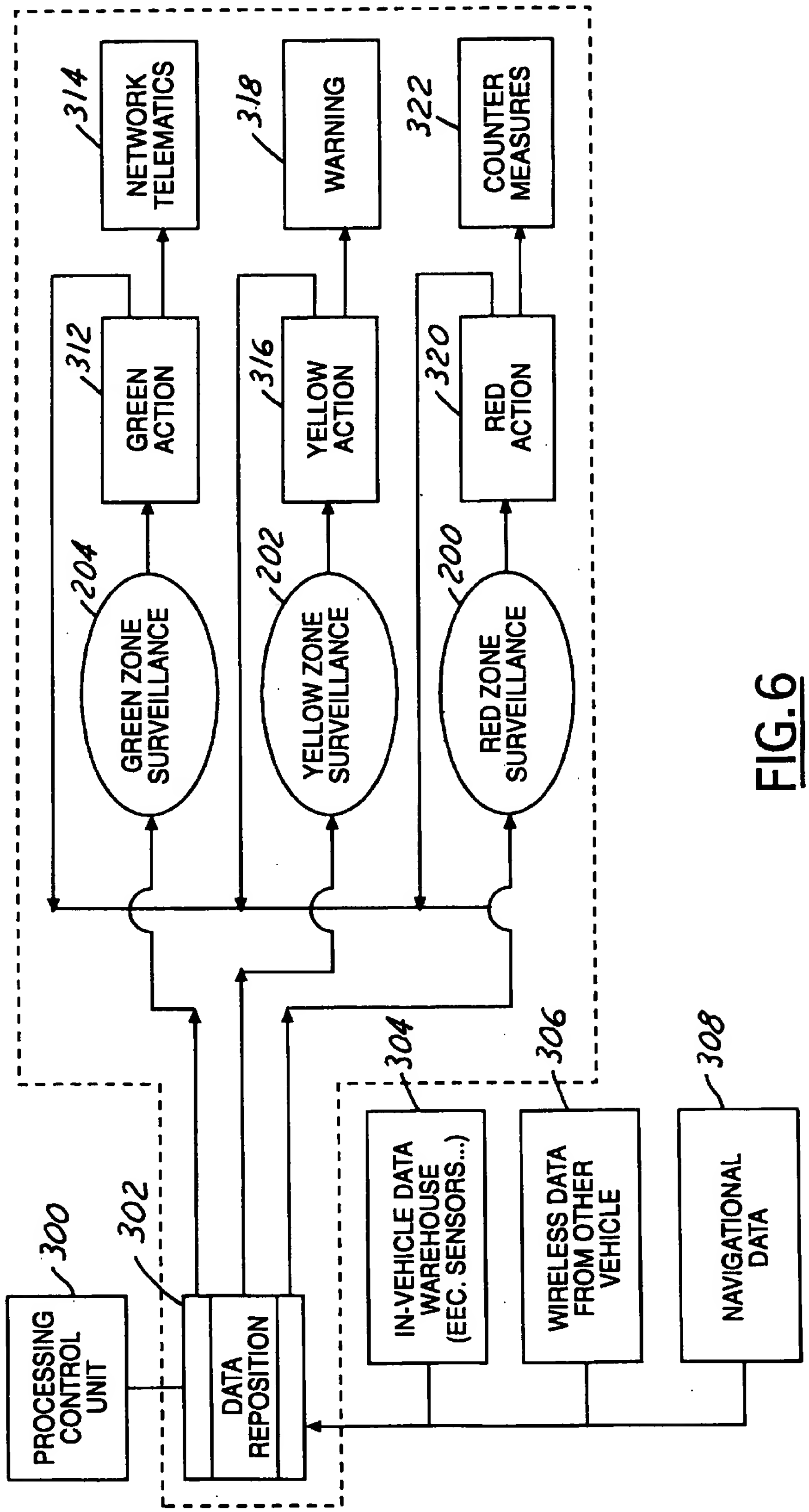
NETWORK TELEMATICS
314
WARNING
318
COUNTER MEASURES
322
GREEN ACTION
312
YELLOW ACTION
316
RED ACTION
320
GREEN ZONE SURVEILLANCE
204
YELLOW ZONE SURVEILLANCE
202
RED ZONE SURVEILLANCE
200
IN-VEHICLE DATA WAREHOUSE (EEC. SENSORS...)
304
WIRELESS DATA FROM OTHER VEHICLE
306
NAVIGATIONAL DATA
308
PROCESSING CONTROL UNIT
300
DATA REPOSITION
302

FIG.6

METHOD AND APPARATUS FOR PRE-CRASH THREAT ASSESSMENT USING SPHEROIDAL PARTITIONING

BACKGROUND OF INVENTION

The present invention relates to pre-crash sensing systems for automotive vehicles, and more particularly, to pre-crash sensing systems having spheroidal partitioning for real-time safety threat assessment.

Auto manufacturers are investigating radar, lidar, and vision-based pre-crash sensing systems to improve occupant safety. Current vehicles typically employ accelerometers that measure forces acting on the vehicle body. In response to accelerometers, airbags or other safety devices are employed. Also, Global Position Systems (GPS) are used in vehicles as part of navigation systems.

In certain crash situations, it would be desirable to provide information to the vehicle operator before forces actually act upon the vehicle. As mentioned above, known systems employ combinations of radar, lidar and vision systems to detect the presence of an object in front of the vehicle a predetermined time before an actual crash occurs. Such systems have expense constraints and can be prone to false positives.

Other systems broadcast their positions to other vehicles where the positions are displayed to the vehicle operator. The drawback to this type of system is that the driver is merely warned of the presence of a nearby vehicle without more. In a crowded traffic situation, it may be difficult for a vehicle operator to react to a crowded display.

Information processing and bandwidth for communications can also limit safety applications. As more sensing devices are implemented, the signals generated must be processed, actions determined, and control signals communicated to safety modules having their own reaction latency. For example, airbag deployment, seatbelt pretensioning, nose dipping and braking have latencies of approximately 100 ms, 180 ms, 300 ms and 400 ms, respectively. Having an intelligent methodology which can learn and make efficient use of processing cycles, available data and communication bandwidth is desirable for a robust in-vehicle threat assessment.

It would be desirable to provide a system that takes into consideration the position of other vehicles and provides adequate warning to the vehicle operator and, should the situation warrant, provides crash mitigation.

SUMMARY OF INVENTION

The present invention provides an improved pre-crash sensing-system using spheroidal partitioning of the vehicle environment to warn the vehicle operator and respond to detected objects.

In one aspect of the invention, a method for operating a pre-crash sensing system for a vehicle having an object detecting system and an associated data storage is provided. The method includes partitioning the vehicle-operating environment into a plurality of zones wherein each zone represents a different area surrounding the vehicle. In response to detecting an object within any one of the zones, the method activates the zone, and modifies an operating state of the object detection system and the contents of the data storage as a function the active zone. In one embodiment, three zones are disclosed wherein each zone represents a spheroidal area the vehicle. When the furthest zone is active, all data within the data storage is given approximately equal processing priority. When the middle zone is active, the content of the data storage is modified to prioritize data regarding the detected object for processing. Finally, when the nearest zone is active, the content of the data storage is further modified to provide highest priority to data regarding the detected object.

One advantage of the invention is that the spheroidal portioning of the vehicle environment allows for prioritizing data processing and communication. This reduces the amount of unnecessary information exchanged and therefore communication is expedited allowing more time for the vehicle operator or countermeasure device to react to a detected object.

Other aspects and features of the present invention will become apparent when viewed in light of the detailed description of the preferred embodiment when taken in conjunction with the attached drawings and appended claims.

BRIEF DESCRIPTION OF DRAWINGS

For a more complete understanding of this invention, reference should now be made to the embodiments illustrated in greater detail in the accompanying drawings and described below by way of examples of the invention.

FIG. 1 is a block diagrammatic view of a pre-crash sensing system according to one embodiment of the present invention.

FIG. 2 is a block diagrammatic view of one embodiment of the invention illustrating a vehicle network established by two pre-crash sensing systems.

FIG. 3 is a perspective view of an automotive vehicle instrument panel display for use with the present invention.

FIG. 4 is a front view of a vehicle network display according to an embodiment the present invention.

FIG. 5 is a schematic diagram of a spheroidal partition of a vehicle environment according to an embodiment of the present invention.

FIG. 6 is a block diagram of a spheroidal threat assessment system according to the present invention.

FIG. 7 is a logic flow diagram of the operation of the spheroidal threat assessment system of FIG. 6.

DETAILED DESCRIPTION

In the following figures, the same reference numerals will be used to identify the same components in the various views.

Referring now to FIG. 1, a pre-crash sensing system 10 for an automotive vehicle 11 has a controller 12. Controller 12 is preferably a microprocessor-based controller that is coupled to a memory 14. Controller 12 has a corresponding CPU that is programmed to perform various tasks, as well as inputs/outputs and a communications bus. Memory 14 is illustrated as a separate component from that of controller 12. However, those skilled in the art will recognize that memory may be incorporated into controller 12.

Memory 14 may comprise various types of memory including read only memory, random access memory, electrically erasable programmable read only memory, and keep alive memory. Memory 14 is used to store various thresholds and parameters including vehicle data 16 as illustrated.

Controller 12 is coupled to a global positioning system (GPS) 18 that receives position data triangulated from satellites as is known to those skilled in the art.

Controller 12 is coupled to a sensor data block 20 that represents various sensors located throughout the vehicle. The various sensors will be further described below.

Controller 12 may also be coupled to a receiver 22 coupled to a receiving antenna 24 and a transmitter 26 coupled to a transmitting antenna 28. Transmitter 26 and receiver 22 may be part of a transponder 27. Transponder 27 can be located at the front of the vehicle 11. Preferably, vehicle has a transponder located on each of the four sides of the vehicle. That is, a rear transponder is located at the rear of the vehicle, a transponder is located on the left side of the vehicle and, a transponder is located on the right side of the vehicle. A radar sensor 29 is located within each transponder. When a radar signal having a certain amplitude is detected, transmitter 26 generates a response that includes its location relative to the vehicle. Other data such as sensor data, position data, and other data may also be communicated. An example of a radar signal is a cruise control signal from an active cruise control system.

Controller 12 is also coupled to a display 30 that may include various types of displays including a vehicle network display, a warning display 34, and a counter-measure display 36. An example of a network display will be described in further detail below. As should be noted, display 30 may be a single display with different display features or may be individual displays that may include audible warnings as well.

Controller 12 has various functional blocks illustrated within CPU 13. Although these functional blocks may be represented in software, they may also be implemented in hardware. As will be further described below, controller 12 has a proximity detector 42 that is used to determine the proximity of the various vehicles around automotive vehicle 11. A vehicle trajectory block 44 is used to determine the trajectory of the vehicle and surrounding vehicles. Based upon the vehicle trajectory block 44, a threat assessment is made in functional block 46. Of course, threat assessment 46 takes into consideration various vehicle data 16 and sensor data from sensor block 20. Threat assessment 46 may be made based upon the braking capability of the present vehicle and surrounding vehicles in block 48 and also road conditions of the present vehicle and surrounding vehicles in block 50. As will be further described below, the road conditions of block 50 may be used to determine the braking capability in block 48.

In block 16, various vehicle data are stored within the memory. Vehicle data represents data that does not change rapidly during operation and thus can be fixed into memory. Various information may change only infrequently and thus may also be fixed into memory 14. Vehicle data includes but is not limited to the vehicle type, which may be determined from the vehicle identification number, the weight of the vehicle and various types of tire information. Tire information may include the tire and type of tread. Such data may be loaded initially during vehicle build and may then manually be updated by a service technician should information such as the tire information change.

Global positioning system (GPS) 18 generates a position signal for the vehicle 11. Global positioning system 18 updates its position at a predetermined interval. Typical interval update periods may, for example, be one second. Although this interval may seem long compared to a crash event, the vehicle position may be determined based upon the last update from the GPS and velocity and acceleration information within the vehicle.

Global positioning system 18 has a clock that is common to all GPS. Clock 19 provides a timing signal. Each of the GPS for different vehicles uses the same clock and timing signal. As will be described below, the common clock for timing signal is used to synchronize the communication between the various vehicles of the system.

Sensor data 20 may be coupled to various sensors used in various systems within vehicle 11. Sensor data 20 may include a speed sensor 56 that determines the speed of the vehicle. Speed sensor may for example be a speed sensor used in an anti-lock brake system. Such sensors are typically comprised of a toothed wheel from which the speed of each wheel can be determined. The speed of each wheel is then averaged to determine the vehicle speed. Of course, those skilled in the art will recognize that the vehicle acceleration can be determined directly from the change in speed of the vehicle. A road surface detector 58 may also be used as part of sensor data 20. Road surface detector 58 may be a millimeter radar that is used to measure the road condition. Road surface detector 58 may also be a detector that uses information from an anti-lock brake system or control system. For example, slight accelerations of the wheel due to slippage may be used to determine the road condition. For example, road conditions such as black ice, snow, slippery or wet surfaces may be determined. By averaging microaccelerations of each tire combined with information such as exterior temperature through temperature sensor 60, slippage can be determined and therefore the road conditions may be inferred therefrom. Such information may be displayed to the driver of the vehicle. The surface conditions may also be transmitted to other vehicles.

Vehicle data 16 has a block 52 coupled thereto representing the information stored therein. Examples of vehicle data include the type, weight, tire information, tire size and tread. Of course, other information may be stored therein.

Sensor data 20 may also include a tire temperature sensor 62 and a tire pressure sensor 64. The road condition and the braking capability of the vehicle may be determined therefrom.

Other system sensors 66 may generate sensor data 20 including steering wheel angle sensor, lateral acceleration sensor, longitudinal acceleration sensor, gyroscopic sensors and other types of sensors.

Referring now to FIG. 2, vehicle 11 may be part of a network 70 in conjunction with a second vehicle or various numbers of vehicles represented by reference numeral 72. Vehicle 72 preferably is configured in a similar manner to that of vehicle 11 shown in FIG. 1. Vehicle 72 may communicate directly with vehicle 11 through transmitter 26 and receiver 22 to form a wireless local area network. The network 70 may also include a repeater 74 through which vehicle 11 and vehicle 72 may communicate. Repeater 74 has an antenna 76 coupled to a transmitter 78 and a receiver 80. Various information can be communicated through network 70. For example, vehicle data, position data, and sensor data may all be transmitted to other vehicles throughout network 70.

Referring now to FIG. 3, an instrument panel 82 is illustrated having a first display 84 and a second display 86. Either displays 84, 86 may be used generate various information related to the pre-crash sensing system.

Referring now to FIG. 4, display 84 is illustrated in further detail. Display 84 can be configured to correspond to the vehicle network display warning display and countermeasure display mentioned above. The vehicle network display 32 may include a map 88, a first vehicle indicator 90, and a second vehicle indicator 92. First vehicle indicator corresponds to the driven vehicle having the present pre-crash sensing system, while vehicle indicator 92 corresponds to an approaching vehicle. Vehicle network display 32 may be

displayed when a vehicle is near but beyond a certain distance or threat level. The vehicles on the display may be those within the field of view or those broadcasting signals as will be described below.

Warning indicators and distance indicators can also be displayed to provide the vehicle operator with an indication of the distance from a detected vehicle or object. The display may indicate a warning when the vehicle is within a predetermined distance or when an urgent threat level exists.

Display 84 can also be configured to a counter-measure display to indicate to the vehicle operator that a countermeasure is being activated because the threat level is high or the distance from the vehicle is within a predetermined distance less than the distances needed for activation of the vehicle network display or warning display.

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Display 84 is a screen-based display such as an LCD, LED, or CRT display, or may be implanted as a heads-up display (HUD) overlaying the forward vision of the vehicle operator to through the windshield. Other known display mechanisms as also contemplated by the present invention.

Referring now to FIG. 5 there is shown a schematic diagram of a spheroidal partition of a vehicle environment according to an embodiment of the present invention. Display 84 or display 86 can be configured to depict a "birds-eye" field of view or overhead field of view for vehicle 11 to communicate information regarding a surrounding environment to the vehicle operator. The environment surrounding the vehicle 11 is divided into three threat assessment zones identified as red zone 200 (T_R), yellow zone 202 (T_Y), and green zone 204 (T_G). Each of the zones 200, 202, and 204 are concentric with the vehicle 11. Similar concentric zones exist for vehicles similarly equipped with a pre-crash threat assessment system. Preferably, the zones are spheroidal and three-dimensional to help determine whether vehicles which appear to be on the same plane are about to collide, such as at an intersection; or whether the vehicles are traveling in different planes, such as when one of the vehicles is on an overpass and does not pose a collision threat with any otherwise adjacent vehicle. The three dimensional information is obtained from the GPS sensing system.

Each of the green, yellow, and red zones describes the temporal relationships surrounding the vehicle 11 and is based on multi-varied information such as vehicle speed, headway distance between other vehicles, geographic information, and driver characteristics, for example.

The green zone 204 represents a low risk zone with long temporal scales. For example, the green zone may represent the region between approximately 30 m and 50 m from the vehicle of interest. In this region, adjacent vehicles are interacting weakly by way of a virtual floating network (FIG. 2) through transponders located on the vehicles. In the green zone 204, information is shared between nearby vehicles enabling traffic monitoring and rerouting, for example, as is necessary or desirable. The green zone 204 is considered a very low threat zone.

The yellow zone 202 represents a moderate risk with temporal scales on the order of approximately one to five seconds. The yellow zone may represent, for example, a region between 10 m and 30 m from the vehicle 11. The threat assessment data is fundamentally different in this region as compared to the green zone 204. Thus, the update and/or refresh rates for the sensors communicating threat assessment data as well as the communication of the respective data occur on faster time scales than in the green zone. For adjacent vehicles, a time-to-collision value between vehicles in close proximity acts as a time boundary within which threat assessments and, if necessary, countermeasure deployment must occur. Accordingly, data communicated on the vehicle network is prioritized such that the most important data is processed first whereas other types of data are given less priority such as navigational data, entertainment data, or other types of convenience items.

Inside the red zone 200, the network is focused only on communication between vehicles in very local proximity representing an impending threat. Thus, there occurs a further data priority as compared to the yellow zone 202. Red zone may represent, for example, the region within 10 m surrounding the vehicle 11. Threat assessment data is filtered and processed based upon identification of the threatening vehicle. If the potentially threatening vehicle 206 is communicating wirelessly with the vehicle 11, the resulting data is processed at the fastest rate and given highest priority. If, however, adjacent vehicle 206 is not wirelessly equipped to communicate with vehicle 11, the sensor or sensor group of vehicle 11 which can uniquely identify vehicle 206 is used and given priority. The type and location data of vehicle 206 is given highest priority in the threat assessment controller of vehicle 11 and monitored continually until an event changes the priority selection for the detected vehicle 206.

The spheroidal partitioning of the vehicle environment for vehicle 11 may be configured such that actions may be taken as corresponding zones of an adjacent vehicle interfere with or are detected within the green, yellow, and red zones 204, 202, 200 of vehicle 11. Thus, when the red zone 208 of vehicle 206 impinges upon the red zone 200 of vehicle 11, actions may be taken. Alternatively, vehicle 206 could be considered to be only within the yellow zone 202 of vehicle 11. Likewise, forward vehicle 210 could be considered to be in the yellow zone 202 of vehicle 11, or entirely outside the green zone 204 of vehicle 11 depending upon the configuration of the areas represented by the respective zones.

In summary, the green zone is characterized by a virtual floating network between all adjacent vehicles and represents a relatively low risk of impact with a detected object due to the long temporal scales involved such as greater than 5 seconds. To the extent that any modification is desired of the vehicle trajectory, it can be accomplished by braking or rerouting suggestions as the vehicles are only weakly interacting with each other. The yellow zone represents a more moderate impact risk wherein reactions are occurring on a scale of between approximately 1 second and 5 seconds. In the yellow zone, the virtual floating network is more properly characterized as a peer-to-peer network between the vehicle 11 and the detected vehicle or object of interest within the yellow zone. In such cases, the vehicle 11 can be said to be moderately interacting with the detected vehicle or object. In order to avoid impending collision, hard maneuvering, for example, may be required. In the red zone, the threat assessment is characterized as high risk due to the short time to impact of approximately less than 1second. In such cases, smart transponders on the vehicle 11 are given highest priority for continuous threat assessment and mitigation in the form of, for example, active countermeasures. In such cases, the vehicle 11 can be said to be strongly interactive with a detected object or vehicle.

Referring now to FIG. 6 there is shown a block diagram of a spheroidal threat assessment system according to an embodiment of the present invention. The control scheme is governed by the processing control unit (PCU) 300 such as the controller 12 of FIG. 1. The PCU is in operative communication with a data repository 302, the content of which is a function of the surveillance zone (green, yellow

or red) active at a given moment in time. The data repository 302 thus can contain information from the in-vehicle data warehouse 304, wireless data from other vehicles 306 as well as navigational data 308 from the GPS or wireless network. The in-vehicle data warehouse 304 contains the vehicle data 16 and sensor data 20 (FIG. 1). The wireless data from other vehicles 306 potentially represents the most critical data source for impact assessment and mitigation since it is enabled by vehicle-to-vehicle communication. Transponder information from transponder 27 can be used to further enhance the information warehouse 304. By aggregating the information and comparing differences between in-vehicle data and shared data, the PCU 300 can determine uniquely the surrounding vehicles, sensing technologies, location, and threat potential of detected objects.

Depending upon whether the red zone 200, yellow zone 202, or green zone 204 is active, different actions are taken as mentioned above. Thus, the green actions 312 include continued information sharing through network telematics 314 to allow for traffic monitoring and rerouting, for example. Yellow actions 316 include prioritizing data within the data repository 302 based upon the time-to-collision of the detected object or vehicle. Data prioritization may include increasing the update and/or refresh rates for the sensors as well as the speed at which communicated data occurs. Data prioritization may also include processing more important data first and moving other data to background processing such as navigational data or entertainment related data. A peer-to-peer network may also be established between the vehicle and the detected vehicle such that mitigating action may be taken in either the driven vehicle or the detected vehicle or both. A yellow action 316 may also result in a warning 318 being displayed within the vehicle.

Red actions 320 include further prioritization of the data repository 302 to filter and process specific data based upon the identification of the detected object or vehicle. Thus, vehicle trajectory data and type and location data is given the highest priority within the PCU 300 and the sensor or sensor set uniquely associated with providing such information is given the highest priority as well. If an impact with a detected object or vehicle is eminent, red actions 320 may include active or passive countermeasures 322.

The green and yellow actions 312, 316 may also transition to a higher priority (red zone surveillance) based upon actions of the vehicle operator in addition to events on the road or with respect to detected objects. For example, referring again to FIG. 5, vehicle 206 in the process of merging into the lane of vehicle 11 would interact strongly with vehicle 11 and depending upon the trajectory of vehicle 206 and rate of change of trajectory, a green zone interaction may change to a yellow zone or a green zone interaction may change directly to a red zone. Similarly, if vehicle 210 was in the green zone of surveillance and the operator of vehicle 11 was, for example, to start talking on the telephone, the green zone surveillance may change to a yellow zone due to the diversion of the driver's attention from the road. In this way, a heightened sense of awareness between vehicle 210 and vehicle 11 can augment the vehicle operator's ability to focus at the task of driving the vehicle 11.

Referring now to FIG. 7, a logic flow diagram of the operation of the spheroidal threat assessment system of FIG. 6 is shown. In step 400, the various sensor data for the system is determined. This includes the sensor data 20 (FIG. 1). In step 402, all the vehicle data is determined such as in included in vehicle data 16 (FIG. 1). In step 404, the first GPS signal is obtained for the vehicle. In step 406, upon the detection of a second vehicle or object within a zone of surveillance, information regarding the second vehicle or object is received from the second vehicle or obtained through sensor detection on the operator's vehicle. The second vehicle information may be various information such as the speed, heading, vehicle type, position, and road conditions from the other vehicle or vehicles in the network. In step 408, the proximity of the first vehicle with respect to the second vehicle is determined. The proximity may be merely a distance calculation. In step 410, the first vehicle trajectory relative to the second vehicle is determined. The first vehicle trajectory uses the information such as the positions and various sensors to predict a path of expected travel for the first vehicle and the second vehicle. In step 412, a threat assessment of the first vehicle trajectory relative to the second vehicle trajectory is determined. The threat assessment can be categorized based upon the severity of or the immediately of the perceived threat of impact. The threat is preferably scaled to provide various types of warning to the vehicle operator as well as the countermeasure system and threat assessment system.

The threat assessment may be made based upon conditions of the vehicle trajectory and vehicle type as well as based upon tire information which may provide indication as to the braking capability of the first vehicle and/or the second vehicle. Thus, the threat may be adjusted accordingly. Also, the road surface condition may be factored into the threat assessment. On clear, dry roads, a threat may not be as eminent as if the vehicle is operating under the same conditions on a wet or snowy road.

Based upon the assessed threat, the appropriate surveillance zone is determined in step 414. Thus, based primarily upon the proximity of the second vehicle, the zone 416, yellow zone 418 or red zone 420 will become active. In addition or alternatively, based upon the vehicle operator's actions what would otherwise be a green zone activation may be indicated as a yellow zone activation or a red zone surveillance. As described with reference to FIG. 6, depending upon the surveillance zone active at a given point in time, the type of data and priority of data in the data repository 302 is modified. As well, the operator display may be modified to indicate the threat assessment and/or active zone of surveillance. In addition, actions associated with the surveillance zone are implemented which, for example, includes a warning for a yellow zone activation, and active or passive countermeasures for a red zone activation as shown in step 422.

As would be evident to those skilled in the art, various permutations and modifications to the above method and system may be performed. For example, information regarding a detected vehicle may be obtained from an autonomous sensing on the operator's vehicle, wireless transponding from surrounding vehicles, or the vehicle's operating environment itself such as in the case of an intelligent intersection having capability to detect and monitor vehicles within its field-of-view and transmit information regarding such vehicles to vehicles in the area having the capability to receive such information.

From the foregoing, it will be seen that there has been brought to the art a new and improved method and apparatus for pre-crash threat assessment using spheroidal partitioning. While the invention has been described in connection with one or more embodiments, it should be understood that the invention is not limited to those embodiments. On the contrary, the invention covers all alternatives, modifications, and equivalents as may be included within the spirit and scope of the appended claims.

What is claimed is:

1. A method for operating a pre-crash sensing system for a vehicle having an object detecting system and an associated data storage, the method comprising:

partitioning the vehicle operating environment into a plurality of zones wherein each zone represents a different area surrounding the vehicle;

in response to detecting an object within any one of said zones, activating said zone; and

modifying an operating state of said object detection system and the contents of said data storage as a function of said active zone.

2. A method according to claim 1 comprising modifying an operator display as a function of said active zone.

3. A method according to claim 1 wherein activating said zone comprises generating a threat assessment value indicative of an impact threat associated with said detected object and activating said zone as a function of said threat assessment value.

4. A method according to claim 1 wherein partitioning comprises partitioning the vehicle operating environment into first, second and third zones wherein the first zone represents an area immediately surrounding said vehicle, said second zone is outside of said first zone, and said third zone is outside of said second zone.

5. A method according to claim 4 wherein each of said first, second and third zones is spheroidal and concentric with respect to the vehicle.

6. A method according to claim 4 comprising deploying countermeasures when said first zone is active.

7. A method according to claim 4 comprising displaying a warning on an operator display when said second zone is active.

8. A method according to claim 1 wherein modifying comprises prioritizing sensor data associated with said object detection system as a function of said active zone.

9. A method according to claim 1 wherein modifying comprises establishing a wireless communication channel between said vehicle and said detected object for receiving object data from said detected object.

10. A method for operating a pre-crash sensing system for a vehicle having an object detecting system and an associated data storage, the method comprising:

partitioning the vehicle operating environment into first, second and third zones wherein the first zone represents an area immediately surrounding said vehicle, said second zone is outside of said first zone, and said third zone is outside of said second zone, wherein each of said zones is spheroidal and concentric with respect to the vehicle;

in response to detecting an object within one of said zones, activating said zone; and modifying an operating state of said object detection system and the contents of said data storage as a function of said active zone.

11. A method according to claim 10 comprising, when said third zone is active, providing approximately equal priority to data within said data storage wherein said data storage contains data from said object detection system, data received from at least one detected object, and data received from a wireless navigational network.

12. A method according to claim 10 comprising, when said second zone is active, establishing a wireless communications channel between said vehicle and said detected object, and assigning greater priority to data within said data storage regarding said detected object than data received from a wireless navigational network.

13. A method according to claim 10 comprising, when said first zone is active, activating counter-measures, and assigning highest priority to data within said data storage regarding said detected object than any other data within said data storage.

14. A pre-crash sensing system for a vehicle comprising:

an object detection system including at least one object detection sensor and providing sensing data;

a transponder for receiving object data from a detected object across a wireless vehicle network;

a navigational system for receiving navigational data regarding the vehicle operating environment;

a data storage in operative communication with said object detection system, transponder and said navigational system for storing said sensing data, object data and navigational data; and

a controller in operative communication with said data storage, said controller including logic programmed to:

partition the vehicle operating environment into a plurality of zones wherein each zone represents a different area surrounding the vehicle; and

in response to detecting an object within any one of said zones, activate said zone and prioritize said sensing data, object data and navigational data as a function of said active zone.

15. A pre-crash sensing system according to claim 14 comprising an operator display and wherein said controller logic is programmed to modify said display as a function of said active zone.

16. A pre-crash sensing system according to claim 14 wherein said plurality of zones comprises first, second and third zones wherein the first zone represents an area immediately surrounding said vehicle, said second zone is outside of said first zone, and said third zone is outside of said second zone.

17. A pre-crash sensing system according to claim 16 wherein each of said zones is spheroidal and concentric with respect to the vehicle.

18. A pre-crash sensing system according to claim 16 wherein said controller logic is programmed to provide approximately equal priority to said sensing data, object data and navigational data when said third zone is active.

19. A pre-crash sensing system according to claim 16 wherein said controller logic is programmed to give higher priority to said sensing data and said object data than said navigational data when said second zone is active.

20. A pre-crash sensing system according to claim 16 wherein said controller logic is programmed to provide highest priority to said sensing data when said first zone is active.

* * * * *

APPENDIX B

Claims 1-17

What is claimed is:

1. A pre-crash sensing system coupled to a countermeasure system having at least a first countermeasure and a second countermeasure comprising:

a vision system generating an object size signal and an object distance signal; and

a controller coupled to said vision system for deploying either said first countermeasure or said first and second countermeasures in response to said object distance signal and said object size signal.

2. A system as recited in claim 1 wherein said vision system comprise a stereo pair of cameras.

3. A system as recited in claim 1 wherein said object size comprises height.

4. A system as recited in claim 1 wherein said object size comprises object area and object height.

5. A system as recited in claim 1 further comprising a vehicle speed sensor generating a speed signal corresponding to the longitudinal speed of the vehicle; wherein said controller activates said countermeasure system in response to the longitudinal speed signal.

6. A system as recited in claim 1 further comprising a decision zone; wherein said vision sensor detects an object and generates an object distance signal from an object within said decision zone.

7. A method for operating a pre-crash sensing system for an automotive vehicle having a countermeasure system, said method comprising:

establishing a decision zone relative to the vehicle;

detecting an object within the decision zone using a vision system;

determining an object distance and relative velocity using a vision system;

determining an object size; and

activating the countermeasure system in response to the object size and relative velocity.

8. A method as recited in claim 7 wherein determining object size comprises determining an object height; wherein activating the countermeasure system in response to the object size comprises activating the countermeasure system in response to the object height.

9. A method as recited in claim 7 wherein determining an object size comprises determining an object cross-sectional area; wherein activating the countermeasure system in response to the object size comprises activating the countermeasure system in response to the object cross-sectional area.

10. A method as recited in claim 7 wherein determining an object size comprises determining an object cross-sectional area and object height; wherein activating the countermeasure system in response to the object size comprises activating the countermeasure system in response to the object cross-sectional and object height.

11. A method as recited in claim 10 wherein determining an object cross-sectional area comprises determining the object cross-sectional area with a vision system.

12. A method as recited in claim 7 wherein detecting an object within the decision zone comprises detecting the object within the decision zone with a stereo pair of cameras.

13. A method as recited in claim 7 wherein prior to the step of activating, choosing the first countermeasure or the first countermeasure and the second countermeasure in response to said object size.

14. A method as recited in claim 7 wherein determining an object size comprises determining the vehicle orientation; wherein activating the countermeasure system in response to the object size comprises activating the countermeasure system in response to the object size and vehicle orientation.

15. A method as recited in claim 7 further comprising establishing a decision zone in front of the vehicle.

16. A method as recited in claim 15 further comprising detecting an object within the decision zone; and activating the countermeasure in response to detecting an object within the decision zone.

17. A method as recited in claim 7 wherein activating the countermeasure system comprises activating a first countermeasure comprising pre-arming airbags and pretensioning motorized belt pretensioners, or activating the first countermmeasure and a second countermeasure wherein said second countermeasure comprises adjusting the host vehicle suspension height in response to object size and orientation.

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FEE TRANSMITTAL for FY 2004

Effective 10/01/2003. Patent fees are subject to annual revision.

☐ Applicant claims small entity status. See 37 CFR 1.27

TOTAL AMOUNT OF PAYMENT	($) 330.00

Complete if Known

Application Number	09/683,782
Filing Date	February 13, 2002
First Named Inventor	Rao, et al.
Examiner Name	Daniel Previl
Art Unit	2632
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METHOD OF PAYMENT *(check all that apply)*

☐ Check ☐ Credit card ☐ Money Order ☐ Other ☐ None

☑ Deposit Account:

Deposit Account Number	06-1510
Deposit Account Name	Ford Motor Company

The Director is authorized to: *(check all that apply)*

☑ Charge fee(s) indicated below ☑ Credit any overpayments

☐ Charge any additional fee(s) or any underpayment of fee(s)

☐ Charge fee(s) indicated below, **except for the filing fee**

to the above-identified deposit account.

FEE CALCULATION

1. BASIC FILING FEE

Large Entity Fee Code	Large Entity Fee ($)	Small Entity Fee Code	Small Entity Fee ($)	Fee Description	Fee Paid
1001	770	2001	385	Utility filing fee	
1002	340	2002	170	Design filing fee	
1003	530	2003	265	Plant filing fee	
1004	770	2004	385	Reissue filing fee	
1005	160	2005	80	Provisional filing fee	

SUBTOTAL (1) ($)

2. EXTRA CLAIM FEES FOR UTILITY AND REISSUE

			Extra Claims		Fee from below		Fee Paid
Total Claims		-20** =		X		=	
Independent Claims		- 3** =		X		=	
Multiple Dependent						=	

Large Entity Fee Code	Large Entity Fee ($)	Small Entity Fee Code	Small Entity Fee ($)	Fee Description
1202	18	2202	9	Claims in excess of 20
1201	86	2201	43	Independent claims in excess of 3
1203	290	2203	145	Multiple dependent claim, if not paid
1204	86	2204	43	** Reissue independent claims over original patent
1205	18	2205	9	** Reissue claims in excess of 20 and over original patent

SUBTOTAL (2) ($)

**or number previously paid, if greater; For Reissues, see above

FEE CALCULATION (continued)

3. ADDITIONAL FEES

Large Entity Fee Code	Large Entity Fee ($)	Small Entity Fee Code	Small Entity Fee ($)	Fee Description	Fee Paid
1051	130	2051	65	Surcharge - late filing fee or oath	
1052	50	2052	25	Surcharge - late provisional filing fee or cover sheet	
1053	130	1053	130	Non-English specification	
1812	2,520	1812	2,520	For filing a request for *ex parte* reexamination	
1804	920*	1804	920*	Requesting publication of SIR prior to Examiner action	
1805	1,840*	1805	1,840*	Requesting publication of SIR after Examiner action	
1251	110	2251	55	Extension for reply within first month	
1252	420	2252	210	Extension for reply within second month	
1253	950	2253	475	Extension for reply within third month	
1254	1,480	2254	740	Extension for reply within fourth month	
1255	2,010	2255	1,005	Extension for reply within fifth month	
1401	330	2401	165	Notice of Appeal	
1402	330	2402	165	Filing a brief in support of an appeal	330.00
1403	290	2403	145	Request for oral hearing	
1451	1,510	1451	1,510	Petition to institute a public use proceeding	
1452	110	2452	55	Petition to revive - unavoidable	
1453	1,330	2453	665	Petition to revive - unintentional	
1501	1,330	2501	665	Utility issue fee (or reissue)	
1502	480	2502	240	Design issue fee	
1503	640	2503	320	Plant issue fee	
1460	130	1460	130	Petitions to the Commissioner	
1807	50	1807	50	Processing fee under 37 CFR 1.17(q)	
1806	180	1806	180	Submission of Information Disclosure Stmt	
8021	40	8021	40	Recording each patent assignment per property (times number of properties)	
1809	770	2809	385	Filing a submission after final rejection (37 CFR 1.129(a))	
1810	770	2810	385	For each additional invention to be examined (37 CFR 1.129(b))	
1801	770	2801	385	Request for Continued Examination (RCE)	
1802	900	1802	900	Request for expedited examination of a design application	

Other fee (specify) ____________

*Reduced by Basic Filing Fee Paid

SUBTOTAL (3) ($) 330.00

SUBMITTED BY (Complete *(if applicable)*)

Name *(Print/Type)*	Jeffrey J. Chapp	Registration No. (Attorney/Agent)	50,579	Telephone	248-223-9500
Signature	Jeffrey J. Chapp			Date	November 18, 2003

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